READING RETARDATION, AUDITORY MEMORY, AND MOTIVATION, IN GRADE IV, V, AND VI, BOYS

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FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Reading Retardation, Auditory Memory, and Motivation, in Grade IV, V, and VI Boys" submitted by Denis Cyril Rodgers, in partial fulfillment of the requirements for the degree of Master of Education.

ABSTRACT

The purpose of this investigation was to attempt the confirmation or clarification of three assumptions regarding the auditory memory of retarded readers, i.e., of students reading below their apparent mental capacity. The assumptions were:

i) that the auditory memory of retarded readers is significantly poorer than that of good readers;

ii) that this poor auditory memory arises in part from distractability, or lack of concentration; and

iii) that increasing the motivation of retarded readers would bring their performance levels on auditory memory tests, up to those of good readers.

iv) It was further assumed that a count of the frequency with which different errors occurred would reveal a pattern of errors for retarded readers, different from the error-pattern of good readers, on the tests of auditory memory.

To test these assumptions, a group of thirty retarded readers was selected from among boys attending fourth, fifth, and sixth grade at three schools in Edmonton, Alberta. The group consisted of the ten most retarded readers from each grade level. When reading age was compared with mental age the median level of retardation was 3.5 years. A control

group of thirty boys was randomly drawn from the same classes.

The auditory tests employed measured memory for digits forward, digits backwards, digits combined, syllables, and sentences. For the digits tests, both the length of the longest span, and the total number of items correctly recalled, were scored.

Each student was tested twice, initially in a neutral situation, where motivation was assumed to be at its normal level, and later in a reward situation, where prospect of reward, encouragement, and knowledge of progress were assumed to increase motivation.

Analysis of the results obtained indicated that in terms of the assumptions stated earlier.

i) retarded readers in this study did achieve lower mean scores on all tests, in both neutral and reward situations, but none of the differences between the total groups reached the .05 level of significance. However, when a subgroup of twelve superior readers was compared with the total retarded group, differences significant at the .05 level emerged on the tests of digits combined and digits backwards, in the reward situation, favouring the superior readers.

ii) and iii) The low score of retarded readers on the digits forward test, in the neutral situation, was interpreted

as being caused by lack of concentration, consequent upon low motivation. In the reward situation, an increase in this score, significant at the .06 level, was credited to the motivational procedures, and taken as evidence that improving motivation does improve the auditory memory of retarded readers. That on the other measures, retarded readers were less successful, suggested that on these tests other factors were involved, in addition to concentration and motivation.

iv) Differences in error-frequency patterns did emerge, with the largest difference being significant between the .10 and .20 levels of confidence. This was the transposition error on the test of digits backwards.

The fact that the test of digits backwards differentiated significantly between the group of retarded readers and the sub-group of superior readers, was the most important finding emerging from the study. It was suggested that this test might be of value for diagnostic purposes. There was also evidence in the study, that severely retarded readers, while scoring lowest on the test of digits backwards, scored higher than average on the test of digits forward. It was felt that the size of the discrepancy emerging, when a student's scores on forward and backward digits, were compared with the norms for his age and I.Q., might indicate a possible reading

problem.

It was further speculated, that the poor performance of retarded readers on the digits backwards test, might betoken the lack of a general cognitive ability, described as the ability to hold a sequence in mind while simultaneously operating on its parts. Further research was suggested to confirm and amplify these findings.

TABLE OF CONTENTS

CHAPTER PAGE

CHAPTER PAGE

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

CHAPTER I

BACKGROUND TO THE PROBLEM

Despite a large and continuing body of research, the problem of why some students fail to read at the level of which they are apparently capable, continues to trouble the reading field. Many contributory causes are known, but the need to identify other causal factors remains urgent. The recognition of such factors would aid not only the recovery of students already retarded in reading, but help to identify in advance students who would find the reading process difficult.

Auditory Memory, Concentration, and Motivation

Studies of retarded readers, that is, readers who are reading several years below expectation as indicated by chronological and/or mental age, have suggested that such students are particularly weak in auditory memory. Such findings are, however, based on a variety of memory tests and, while agreeing in their general conclusions, conflicting evidence has been offered as to which tests best typify weakness in auditory memory.

Memory appears related to concentration, since the greater the attention to the initial stimulus the greater

the likelihood of accurate recall. Thus, Sandstedt (1964) considered that an auditory memory span battery tested the child's ability to concentrate and sustain attention.

If the retarded reader's poor memory is caused at least partly by inattention or distractability, is this in turn a reflection of low motivation? The poor reader often knows that he is a failure in reading - and in other subjects also. In a rigid grading system he may have been kept back among younger children. Retarded readers do become dispirited, and it may well be that on any type of verbal test they are less motivated than the child who customarily meets success in his school work.

Walters and Kosowski (1963) found that on a task involving auditory memory of tones, retarded readers who were rewarded for success, did as well as average and good readers, while non-rewarded retarded readers scored below all other groups. The authors suggest that unless highly motivated, retarded readers tend to be less attentive to stimuli.

Summary of the Problem

In brief, research suggests the following of retarded readers:

i) Their auditory memory is poor;

ii) Poor auditory memory may be caused, at least partly, by inattention or lack of concentration;

iii) A possible cause of inattention may be low motivation arising from failure in reading.

II. PURPOSE OF THIS STUDY

The purpose of this study was to attempt to find answers to the following questions:

a) Do retarded readers as a group score significantly low on tests of auditory memory?

b) Does increased motivation significantly improve the performance of retarded readers on tests of auditory memory?

c) On the basis of the answers to the foregoing questions does it appear likely that retarded readers suffer from lack of concentration <u>or</u> poor auditory memory <u>or</u> both?

A supplementary section of the study examined the <u>types</u> of errors commonly made by retarded readers to determine whether - and in what ways - these differed from the error-patterns of the control readers.

III. HYPOTHESES

In the verbal form, the hypotheses tested by this investigation may be stated as follows:

1) In the neutral situation, retarded readers score significantly lower on tests of auditory memory than do

competent readers.

2) In the reward situation, retarded readers score as well as do competent readers.

3) Between the neutral and reward situations, retarded readers show a significant improvement in scores on the auditory memory tests.

4) Retarded readers in both neutral and reward situations, commit certain errors with a greater degree of frequency than do members of the control group.

In the operational null form, these hypotheses read:

1) In the neutral situation there are no significant differences between mean scores of the retarded and control groups, on the tests of auditory memory.

2) In the reward situation there are no significant differences between mean scores of the retarded and control groups on the tests of auditory memory.

3) In the reward situation there is no significant improvement in the mean scores of the retarded readers on the tests of auditory memory.

4) In the neutral and reward situations, there are no significant differences between retarded and control groups, in the relative frequency with which the various types of error occur.

IV. DESIGN OF THE STUDY

From a sample of 320 boys in Grade IV, V, and VI, a group of thirty retarded readers was selected comprising the bottom 10 per cent of each grade level when reading age was compared with both mental and chronological age. A control group was randomly drawn from the same sample. Students in the groups were individually tested on four measures of auditory memory - Digits Forward, Digits Backward, Memory for Syllables, and Memory for Sentences. Each student was tested twice, with a two week interval between testing. The initial tests were carried out in a neutral atmosphere with no indication of the correctness of the student's replies. The second testing occurred under reward conditions, aimed at increasing motivation as much as possible. Group mean scores were compared for each sub-test in both neutral and reward situations, and 't' tests were applied to determine the significance of differences in means, also, where appropriate, an analysis of covariance was made.

The frequencies with which the possible types of errors occurred in the two groups were also compared, and significance of the differences in error-frequency was determined by the t-test for percentages.

A pilot study with fifteen boys from Grade V preceded the main study, to determine the effectiveness of proposed measures and procedures.

V. DEFINITIONS OF TERMS

Auditory Memory. As measured in this study, auditory memory is the ability to repeat orally that which the subject has just heard spoken.

Concentration. In this study concentration refers to the degree to which the student gives and sustains attention to the task in hand.

Motivation. Motivation in this study, refers to the urge that a student feels to attempt the task presented to him.

Total Population. In this study, total population refers to all boys in Grades IV, V and VI attending separate (i.e. Roman Catholic) schools in Edmonton, Alberta, at the time of the experiment.

Sample Population. With the assistance of the administrative staff of the Edmonton Separate School Board, schools were chosen which seemed likely to include among their pupils

a sufficiently large number of boys reading below their apparent capacity. The boys attending Grade IV, V, and VI at St. Angelas and St. Mathews Schools, plus the Grade VI boys at St. Alphonsus School, constituted this sample population.

Retarded Group. The retarded group in this study consisted of the ten boys at each grade level whose reading age was most retarded when compared with chronological and mental age. (See Table I, page 48.) Mental age was obtained from results of the Lorge-Thorndike non-verbal intelligence test.

Control Group. The control group comprised ten students from each grade level, selected from the sample population by the use of a table of random numbers.

Span Score. The auditory digit span sub-tests require the subject to repeat a series of digits after the examiner. In the case of digits backwards the student must reverse the digit order. If at the first attempt at a series the student fails, he is given a second series of the same length to try. The student proceeds until he fails on two successive attempts. The span score indicates the length of the longest span correctly repeated, regardless of whether one or two attempts were required then, or earlier.

Unit Score. The unit score takes the total number of digits read to the student and subtracts from it the number of errors made; a boy reading a series correctly at the first attempt being credited with the second line of the series. As an example, for a boy with a span score of five, the corresponding unit score could be as low as twelve or as high as twenty-four, since twenty-four digits are included in the test, to the end of the second five-digit span. The unit score is, therefore, more sensitive than the span score to differences between students. This method of unit scoring was devised by the writer.

Neutral Situation. The neutral situation in this study was the initial interview in which it was desired to test the child when he was operating close to his normal level of self-motivation. Rapport was established through a standard form of greeting and opening questions. When the auditory tests were administered, no acknowledgement was made of the student's answers. At the close of the neutral situation each child was thanked and praised in a standardized manner.

Reward Situation. In this study the reward situation refers to the second testing, where it was intended to improve

students' motivation by social and material reinforcement. Rewards used are described in Chapter III.

Reading Age. Reading Age in this study was calculated by adding 5.0 to the reading grade obtained from the Van Wagenen Unit Scale of Attainment: Reading Comprehension.

VI. LIMITATIONS OF THIS STUDY

The investigator recognizes a number of limitations of this study.

Larger Sample. The study would undoubtedly have benefitted from the use of larger retarded and control groups. However, the problems of extending the socio-economic range of students involved was a factor here, as also was the need for individual testing by one examiner.

Degree of Retardation. Not all the retarded group can be described as severely retarded, since although the median difference between mental age and reading age was 3.5 years, (range 1.0 yrs. to 6.0 yrs.), nine of the group were less than two years retarded.

Knowledge of Failure. Since a continuous progress plan was followed in the schools from which the population was

drawn, the number of students required to repeat a grade was unusually small. Thus, the retarded readers had not known the degree of failure they would probably have encountered in a more rigid grade system.

Boys Only. No girls were used in this study since there is some experimental evidence to show that girls differ from boys in their reaction to reward - particularly to verbal encouragement.

Auditory Memory and Reading. This study did not attempt to show a causal relationship between poor auditory memory, (and/or concentration), and reading, but tried to establish that on certain tests of auditory memory, retarded readers functioned with significant difference in type and degree of error.

Auditory Memory. It is recognized that what is measured by the tests used in this study is recall after a very brief interval, rather than long term memory.

Retarded Readers in the Control Group. So that the Control Group might be truly representative of the total population the names of the retarded readers were left in when the random selection of the Control Group was made. The

Control Group therefore includes five retarded readers - three from Grade IV, one from Grade V, and one from Grade VI. Nevertheless, the proportions of high, average, and poor readers in the Control Group remained satisfactory. (See Table II, page 49).

Reinforcement. Reinforcement in this study was limited to the prospect of an edible reward, the stimulus of attempting to surpass a previous performance, and the praise of the examiner. It is recognized that not all students may have reacted favourably to these reinforcements.

Effects of Practice. Since there was no non-rewarded group, it is not possible to separate the possible effects of reinforcement from the effects of practice in this study.

VII. NEED FOR THIS STUDY

Several factors suggest the need for the present study:

1. While the consensus of research evidence indicates that retarded readers do have a below-normal auditory memory, investigators to date have failed to clearly establish the particular auditory tasks which most indicate this weakness.

   By restricting this investigation to auditory memory span

alone, and by including auditory tests seemingly related to the reading process, it was hoped to establish more clearly the area of significant weakness.

II. Many of the earlier studies used results from sub-tests of the Wechsler Intelligence Scale for Children, given at various times by various examiners. With auditory memory tests in particular, the manner of delivery greatly influences the likelihood of success, so that use of one examiner was considered important.

III. The complete WISC test is quite long, and should the child become weary it may well be the auditory span test results which would be most affected. In this instance, the tests of auditory memory were the only ones given.

IV. All recent research on Auditory Digit Span sub-tests has reported only the combined scores of Digits Forward + Digits Backwards. This study compared results of the Forward and Backward sub-tests separately - which, as Chapter II indicates, may be an important difference.

V. The question of the influence of motivation on the auditory memory test results of retarded readers, does not appear to have been widely explored. Walters and Kosowski (1963) employed auditory tones rather than words, syllables, or sentences.

Whether or not the retarded reader has a poor auditory memory, and if such a weakness can be counteracted by increased motivation are obviously important questions for workers in the reading field. It is hoped that this study may add to or clarify knowledge in this area.

VIII. ORGANIZATION OF THE REPORT

In Chapter I the problem was identified and the particular approach employed in this study was briefly described. Research studies and literature related to the problem are presented in Chapter II. Chapter III describes the methods for selecting the sample, the testing instruments and procedures, the pilot study and the statistical treatment of the data. The results of the statistical analysis are reported and interpreted in Chapter IV. The conclusions based on the findings, together with the implications for further research, are presented in Chapter V.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter reviews literature related to the present study concerning the auditory memory of retarded readers, auditory memory and auditory memory span, auditory memory span and the ability to concentrate, and the motivation of retarded readers. The chapter closes with a brief summary.

I. THE AUDITORY MEMORY OF RETARDED READERS

Vernon (1957, page 60-61) quotes several studies which found that the auditory memory of retarded readers was unusually poor. Fildes (1921) found that very backward readers had difficulty in remembering both numbers and words presented auditorily. Lord, Carmichael, and Dearborn (1925) reported that, of twenty-five very backward readers having normal intelligence, 64 per cent were deficient in auditory memory of both numbers and letters. Rizzo (1939) found that the auditory memory span for the poorer readers in a group of 310 children was distinctly less than that of the better readers. Similarly, Wolfe (1941) reported eighteen very backward readers as being significantly poorer in auditory memory for words than were the control cases. Johnson (1955) showed

that of a group of thirty-four very backward readers, 70 per cent had a deficient auditory memory span.

These studies, then, support in general terms, Vernon's observation that retarded readers appear to have an unusually poor auditory memory. Research during the last decade has further investigated this relationship.

Studies of WISC Sub-test Results

A number of recent studies in this area have examined the WISC profiles of retarded readers. Although the digit span test is included in the Wechsler Adult Intelligence Scale, it is optional when administering the children's scale. Since digit span is of particular concern to this study, the research reviewed here will largely be that in which the digit span sub-test was included.

Burks and Bruce (1955) compared the WISC profiles of eleven good readers and thirty-one poor readers who were students from Grade II to Grade VIII, inclusive, reading one year or more above or below their actual grade level. The authors describe the poor readers as scoring significantly lower on the tests of Information, Arithmetic and Coding than the good readers. The data also show digit span scores as lower, but the degree of significance is not given.

Altus (1956) reports findings somewhat at variance with other investigators. Describing the WISC profiles of twenty-four boys and one girl, all two or more years retarded when reading age was compared with mental age, she lists Coding and Arithmetic as being relatively low, with Digit Span and Vocabulary scores as being relatively high. Grade level of these students was from Grade III to Grade VIII, inclusive.

Santucci (1959, quoted by Paterra) reports on WISC tests given to thirteen boys and eight girls, all twelve years old and academically retarded, and makes the comment that the degree of academic retardation appears to be related, among other things, to capacity for memorization.

Hirst (1960) divided thirty remedial readers into two groups - Mildly Retarded (reading age .5 to 2.0 years below Mental Age) and Severely Retarded (Reading Age 2+ years below Mental Age). She found low scores on the WISC sub-tests of Coding, Arithmetic and Digit Span to be typical of the Mildly Retarded. The same weaknesses identified her Severely Retarded group.

Neville (1961) matched thirty-five retarded readers (reading more than two years below grade level) with thirty

five retarded readers (reading more than two years below grade level) with thirty-five non-retarded readers. All the subjects were boys. There was a significant difference in means at the .01 level of significance on the sub-tests of Information, Arithmetic and Digit Span. The last test was not given to all students.

WISC sub-scores were studied for a much larger group than usual by Coleman and Rasof (1962) who compared twenty "over-achievers" with 126 "under-achievers." Quoted by Robinson (1964, page 337), they report that under-achievers scored significantly low on sub-tests heavily loaded with "school type learning, concentration and memory factors."

In a study of the WISC scattergrams of thirty-three retarded readers Paterra (1963, page 404) found "poor vocabularies and memorization abilities." Specifically, she reports low scores in Vocabulary and Arithmetic, with no mention of Digit Span scores. Children in this study were boys and girls, with an age range of 6.4 to 14.5 years. Retardation was defined as "not reading at the level expected of the reported mental age."

A further study summarized by Robinson (1964, page 374) dealt with the performance of teen-age disabled readers (age 16.1 to 19.4). The author, MacDonald, compared the sub-scores

of sixty youths on the Wechsler Adult Intelligence Scale. Significant weaknesses appeared in the scores for Information, Arithmetic, Digit Span and Coding.

The last study of WISC sub-scores to be reported here, is one which found the Digit Span sub-test to be influential in lowering the total Verbal Scale IQ for the retarded readers tested. Robeck (1963) examined the WISC records of sixty-eight boys and twelve girls, ranging in age from 6.10 to 13.9 years. All students had been referred to a remedial reading clinic for assistance. The author reports significant weaknesses in Information, Arithmetic and Digit Span. Thus, of the group of eighty students, 45 per cent were significantly low in Information, 70 per cent significantly low in Arithmetic, and 67 per cent significantly low in Digit Span. Reporting on this last sub-test, the author comments (page 125), that, "Digit Span was so highly related to reading disability in this sample, that two-thirds of the Verbal Scale I.Q.'s were lowered appreciably by inclusion of this test."

Summary of Findings on the WISC

Studies by Burke and Bruce (1955), Altus (1956), Santucci (1959), Neville (1961), Coleman and Rasof (1962),

MacDonald (1963) and Robeck (1963) have been briefly described.

Analyzing the performance of retarded readers on the various sub-tests of the Wechsler Intelligence Scale for Children, these investigators have variously reported weak performances on the tests of Arithmetic, Coding, Information, Digit Span and Vocabulary.

Stanford-Binet Sub-test Results

As an individual measure of intelligence, the Stanford-Binet test is often used, and one investigator, Rose (1958), made a particular study of the results of the sub-tests for auditory memory span (digits) obtained from 113 remedial reading cases. All students involved were reading two or more years below the level indicated by their mental age. Rose found that excluding sub-tests where reading was required, more of her group of retarded readers failed the test of auditory memory span, than failed any other test. This discrepancy held true at all but the ten year old level and at the superior adult level. In all, subjects failed the test of auditory memory two-thirds of the time. She comments, (page 463), "It is evident that the tests for auditory memory span are indeed more difficult for a large percentage of the children having reading difficulties, than for the average child."

Other Studies of Auditory Memory and Reading Retardation

Sandstedt (1964) selected from the records of a reading centre the test results of forty-five students ranging in age from eight to thirteen years, with a reading disability of at least two years when reading achievement was compared with reading capacity. These students had completed the WISC and the Detroit Tests of Learning Aptitudes. From this last battery Sandstedt extracted the results of three sub-tests of auditory memory span and two sub-tests of visual memory span. Following a series of comparisons, Sandstedt reported, among other findings, that total auditory memory span scores for these retarded readers tended to be significantly lower than total visual memory span scores.

Raymond (1952) selected a group of high achieving readers defined as having a reading age two years above mental age. She listed their scores on the Binet Intelligence Test, three tests of associated learning, and nine tests of memory span. After making comparisons between the results, she compared her findings with those of Stauffer (1948) who had carried out a similar study with fifty-one severely retarded readers. Raymond states first that achieving readers make mental age scores on the auditory digit span tests (both forward and backward) not significantly different from their

Binet scores. The reverse is true of Stauffer's retarded readers, who made mental age scores on the auditory digit span tests significantly below their Binet mental age scores. In addition, on the tests of Auditory Memory for Sentences, achieving readers rate "superior" by comparison with the "mediocre" rating achieved by the retarded readers.

In another attempt to identify the auditory problems of pupils with reading difficulties, Poling (1953) tried to determine the relative contribution to poor reading of auditory acuity, auditory discrimination, and auditory memory. From the records at a reading centre, Poling selected those of seventy-eight poor readers having average intelligence, and being between eight and thirteen years of age. Poling first identified two groups having high and low auditory acuity and compared their mean reading test scores. Next, she identified high and low auditory discriminators, and, finally, groups scoring high and low in auditory memory. No significant relationship emerged between reading scores and auditory acuity alone, auditory discrimination alone, or auditory memory alone. However, when a group of nine students adequate in acuity, high in discrimination, and high in memory was compared with a group similar in acuity and discrimination but low in auditory memory, significant differences emerged between

their mean reading test scores. Poling interprets her data as lending support to the belief that auditory acuity and discrimination are not widespread causes of inefficient word recognition, but that auditory memory span may be. The auditory memory span test used here requires the child to write down nonsense words immediately after they have been dictated to him. It is of interest that when dividing her total group into high, average and low groups, Poling found that less than 25 per cent of students ranked low in auditory acuity or auditory discrimination, while in auditory memory the low group contained 50 per cent of all the students.

Summary of Studies Concerning the Auditory Memory of Retarded Readers

1. That retarded readers have a generally poor auditory memory:

   Supporting: Johnson (1955)
   Santucci (1959)
   Coleman & Rasof (1961)

2. That retarded readers have a poor auditory memory for letters:

   Supporting: Rizzo (1939)
   Poling (1953)

3. That retarded readers have a poor auditory memory for words:

   Supporting: Fildes (1921)
   Lord et al. (1925)
   Wolfe (1941)
   Sandstedt (1964)

4. That retarded readers have a <u>poor auditory memory for sentences</u>:

   Supporting: Sandstedt (1964)
   Raymond (1952)

5. That retarded readers score <u>low on the WISC sub-test for Vocabulary</u>:

   Supporting: Paterra (1963)
   Contrary: Altus (1956)

6. That retarded readers score <u>low on the WISC sub-test of Information</u>:

   Supporting: Burks & Bruce (1955)
   Neville (1961)
   MacDonald (1963)
   Robeck (1963)

7. That retarded readers score <u>low on the WISC sub-test of Coding</u>:

   Supporting: Burks & Bruce (1955)
   Altus (1956)
   Hirst (1960)
   MacDonald (1963)

8. That retarded readers score <u>low on the WISC sub-test of Arithmetic</u>:

   Supporting: Burks & Bruce (1955)
   Altus (1956)
   Hirst (1960)
   Neville (1961)
   Paterra (1963)
   MacDonald (1963)
   Robeck (1963)

9. That retarded readers have a <u>poor auditory memory for digits</u>:

Supporting: Fildes (1921)
Lord et al. (1925)
Burks & Bruce (1955)
Hirst (1960)
Neville (1961)
MacDonald (1963)
Robeck (1963)
Rose (1958)
Raymond (1952)
Contrary: Altus (1956)

While differing as to which tests in particular most typically exemplify the weaknesses of the retarded reader, all the eighteen studies described above support the view that the majority of retarded readers are notably poor on tasks which involve auditory memory factors.

II. AUDITORY MEMORY AND AUDITORY MEMORY SPAN

While it may well be that low scores on the WISC subtests of Information, Vocabulary and Arithmetic are indicative of the retarded reader's poor auditory memory, so many other factors would seem to be involved that it is difficult to measure the degree of effect exerted by memory alone. It would appear that auditory memory can be most simply - and distinctly - estimated by tests of auditory memory span, but in doing so it is necessary to keep in mind that "memory" and "memory span" are not synonymous terms. As Sandstedt (1964)

observes, memory span is generally defined as the ability of an individual to reproduce correctly after one presentation a series of discrete stimuli. Notable here is the immediacy of the response. Weiner (1966) suggests three stages in retention: an initial period involving sensory or ideational registration and fixation; an intervening period in which the memory trace is latent; and a third step of recall or evocation. Tests of auditory memory span omit the latency period almost completely, and, since the stimulus is presented once only, they greatly reduce the registration or fixation period. Raymond (1952) points out that the "stamping-in" process involved in memorizing requires more mental energy than the mere "grasp" demanded by tests of memory span.

There is however, considerable evidence that the retarded reader is distinguished from the good reader not only by a generally poorer auditory memory, but specifically by a poorer auditory memory span. Many of the studies described above utilized tests of auditory memory span - including those for auditory memory of letters, syllables, sentences, and, most notably, digits. In the brief review of studies especially related to auditory memory span which follows, the writer is particularly indebted to the Raymond (1952) study.

Review of the Literature Related to Auditory Digit Span

In 1885 Ebbinghaus reported on the basis of studies carried out with school children, that length of memory span increases with chronological age. Two years later Jacobs (1887) noted that memory span for numerals and letters appeared to be related to order of achievement in school grades. This was later confirmed by Winch who presented series of consonants to girls in the eight to fourteen age range, to determine the average length of their visual and auditory memory spans. Winch commented that school proficiency appeared to be generally (though not invariably) accompanied by good memory of the kind being tested.

An early suggestion of a span limit was made by Bolton (1890) who conducted tests of digit span with classroom groups. Bolton's conclusions were that a span limit for school children was six digits, that span grows with age rather than intelligence, and that girls have longer spans than boys.

Binet and Henri (1894) carried out the earliest extensive examination of children's memory spans for unrelated words, and for sentences. Working with 510 children, they arrived at the following conclusions:

Unrelated Words: i) The number of words recalled (Unit Score) increases with age.
ii) The span increases slightly as the number of words increases.
iii) Words of significance to the children were recalled better than others, regardless of position in the series.
iv) Sentences. Sentence memory span shows a slight but constant increase with age.
v) Sentence memory (i.e. for related material) in their study was twenty-five times superior to memory for unrelated materials (words).

Also dealing with sentence memory was a study by Squire (1912) who compared the performance of a group of retarded children (nine - eleven years) with a non-retarded group. She found that the retarded children recalled fewer sentences than the non-retarded children of the same age range.

Another comparison study, this time dealing with digit span, split a total of 400 children into approximately equal groups, labelled "feeble-minded," "borderline," "backward" and "adequate". The investigator, Sherman (1923), concluded that the inability to repeat five or more digits at the age of nine years might be considered a sign of feeblemindedness.

The suggestion that auditory digit span might be related to intelligence received further support from a study by Jones (1925) who examined the results of digit span tests obtained from 120 superior children, (from 3-11 to 14-9

years). The scores indicated a positive relation between length of span and intelligence.

Two studies involving large groups of children were reported in 1924 and 1928 respectively. Apart from confirming the average digit spans possessed by children at various age levels, they also pointed up differences of performance on the tests of forward digit span and backward digit span. Thus, Starr (1924) tested 2000 children on forward digits, and 1450 of them on backward digits also. Her sample was divided into groups of normal, retarded, subnormal, and low grade defective. For the normal group she found that both forward and backward digit spans increased in steps. Of the two spans, the backward was the shorter - usually by two digits. Thus, her normal children in the nine - eleven age range had a mode of six digits forward and four digits backward. Starr suggested that the backward digits are superior to forward digits for diagnosis. She felt a low backward digit score might be an early indication that the individual was falling appreciably below his group. (Quoted by Raymond, 1952, page 25).

McCauley was also interested in the diagnostic value of the forward and reverse digit spans. She reported in 1928 on results obtained from 1534 school children. A group

described as "markedly successful" in school was compared with a group of "recognized inability" in school. Comparing each child's score with the norm for his age, McCauley found that on the forward digits test of the "successful" group, 92 per cent equalled or excelled the norm compared with 57 per cent of the "unsuccessful" group. The backward digit span test showed even more notable differences. Among "successful" students 90 per cent equalled or excelled the norms for backward digits, but the same was true of only 23 per cent of the "unsuccessful" group. However, McCauley notes that of the "unsuccessful" group 97 per cent had Binet I.Q.'s below 100. Among McCauley's conclusions are:

1. Memory span is dependent upon age and mental development.
2. The reverse span test is more highly diagnostic than the forward test.

As stated previously, the majority of recent studies have not separated forward from backward digits. One exception to this was the study of Stauffer (1948). Investigating the interrelationships among the scores on tests of memory span for fifty-one severely retarded readers, (age 9.0 - 11.0) Stauffer agreed with Starr and McCauley that, "Retarded readers achieve significantly higher scores on forward span tests than on reverse span tests." Stauffer's group though severely retarded in reading, was of average intelligence.

In 1955 Johnson published the results of an intensive

study of the pre-tests and daily records of thirty-four children attending a remedial reading centre. She compared the memory span scores with that to be expected on the basis of the total Binet I.Q. Her findings included the following percentages of children with low scores:

Memory Span for Related Auditory Materials
- 79 per cent with low scores

Memory Span for Forward Digits
- 68 per cent with low scores

Memory Span for Backward Digits
- 86 per cent with low scores

Johnson comments (1955, page 572) "Deficiencies in memory span appear to be an outstanding characteristic of severely retarded readers," and in a summary of factors related to disability in reading, the same writer (Johnson, 1957) suggests that characteristic of the severely retarded reader is an ability to repeat digits backwards, inferior to his ability to repeat digits in forwards, to a degree beyond that normal for his age and I.Q.

Summary of the Literature on Auditory Memory Span

Research in the area of memory span, exemplified by the studies described above, confirms that -

i) Memory Span increases with age
ii) Memory Span increases with intelligence
iii) Reverse (digit) memory span is shorter than forward memory span.

It is also clear however, that on tests of auditory memory span, retarded readers as a group fail to achieve the level to be expected of them on the basis of their chronological age and I.Q. This failure on tests of auditory memory span has been observed to a degree on tests of forward digits, it has been reported to occur to a greater degree on tests of related materials (sentences) and the failure has been most observed on memory span tests for backward digits.

III. AUDITORY MEMORY SPAN AND THE ABILITY TO CONCENTRATE

It was pointed out earlier in this chapter that auditory memory span tasks differ from the normal concept of memorizing in that the response required follows immediately after the hearing of the stimulus. It cannot be said, however, that no retention is involved. Since more than one digit or letter or word is read by the examiner, the child must obviously hold the items first presented in his memory at least until the examiner completes the series. Is it possible that during this brief interlude the memory trace acquired by the retarded reader decays more rapidly than does the memory trace made by the same stimulus operating upon a good reader?

A study dealing with this particular question was

carried out by Alwitt (1963). Nineteen non-readers (i.e. reading 1.5 years below grade placement), were matched against a group of students of the same age, who were reading at or above grade level. Two visual presentations were made of a series of cards each printed with eight digits, arranged in two rows. On the first series of presentations, the child was told immediately before the card came into view which of the two lines of digits to report. During the second presentation, the child was told immediately after the visual presentation which line to report. Alwitt considered that when the mean scores obtained on the two situations were compared, any difference would reflect the extent of decay of the immediate-memory traces. As anticipated, scores obtained when the children were cued before the presentation, were higher than when the instructions followed the presentation, however, the difference was not greater for the disabled readers than for the competent readers, although competent readers did better on both tests than did the disabled group. Alwitt concluded as a result of the study, that immediate memory traces of reading disability cases do not decay at a faster rate than do those of normal readers.

Writing in 1957, Hunter (page 155) commented that:

> The question of improving memory breaks down into three questions. First, can learning be improved? Second, can retaining be improved? Third, can remembering be improved? The answer to the first of these questions is affirmative. The answer to the second and third is almost certainly negative.
>
> All this being so, the question of how we can improve our memory reduces, in effect, to the question of how we can learn to learn better...
>
> All improvement in memory consists in the improvement of one's habitual methods of recording facts.

Do the retarded reader's "habitual methods of recording facts" differ from those of the competent reader?

Wechsler (1958, page 71) commenting on the digit memory sub-tests of the WISC, observes that, "Difficulty in the reproduction of digits correlates with lack of ability to perform tasks requiring concentrated effort. Individuals with these defects seem to have a special difficulty repeating digits backwards." Wechsler also refers to the factorial study of the WISC sub-tests carried out by Cohen, who suggested that the tests of digit span measured a factor he labelled, "freedom from distractability."

Vernon (1957, page 60) suggested that while the unusually poor auditory memory of retarded readers does not in most cases arise from poor auditory acuity, it might possibly be due to inattention.

Coleman and Rasof (1962) refer to "concentration and memory factors" and a similar, but more expanded view is

given by Sandstedt (1964). After studying the results obtained by forty-five retarded readers on five tests of memory span (both auditory and visual) she considered, (page 249), that the results of such memory span tests showed, "the individual's pattern of ability to concentrate and sustain attention."

There is clear experimental evidence that when a subject's attention is distracted his accurate recording or remembering of stimuli is affected. Thus Gardner and Lorenz (1961) flashed on a screen for one half-second a geometric design. Two seconds later a paired figure was also exposed for a half-second. Then the subjects were asked to draw the two designs. The figures were patterned to make it as easy as possible for the subjects (unconsciously) to "assimilate" them, i.e. to transpose parts of one into the other. Subjects in this study consisted of two groups of fiften women. The first group saw the four pairs of designs, presented as described. The second group completed the first two designs in the same way, but during the showing of pairs three and four, had as a group to count aloud backwards by twos. The completed pairs of drawings were examined for examples of "assimilation" (i.e. features of one drawing wrongly transposed to another). Gardner and Lorenz thought it likely that

the distracted group would show significantly more transpositions in their drawings than the control group, and this was borne out by the data. On pairs one and two, where there were no distracting conditions, there was no difference between the groups in terms of assimilations.

If, as shown here, reducing attention also reduces the accuracy of recall of the stimulus, will increasing attention also increase the accuracy of recall?

Weiner (1966) reviewed "a vast array of studies relating motivation and memory." He included both studies in which the motivational manipulation took place during memory trace formation, and those in which the manipulation of motivation occurred during trace storage or retrieval. While finding that many studies were methodologically inadequate and had yielded some conflicting results, he concluded that substantial evidence has been provided that motivation influences the storage and retrieval of memory traces.

If, as suggested by Vernon and others, the poor auditory memory of the retarded reader arises from a low level of attention, then, in accordance with the findings of Weiner, it seems possible that increasing motivation will raise both attention level and accuracy of auditory memory for the disabled reader.

IV. MOTIVATION AND RETARDED READERS

The literature on motivation is too extensive for adequate summary here, for as Travers (1965, page 46) points out:

> The study of motivation continues to attract enormous amounts of time, labour and research money. And deservedly so, since all animal and human behaviour is activity which receives its energy from the motivational process.

Research on motivation is largely of interest to this particular study only insofar as it relates to school children in general and to retarded readers in particular. Of the very small number of motivational studies which used retarded readers as their subjects, two are of special interest.

Walters and Doan (1962) reported a study involving three groups of eighteen boys drawn from Grades VII and VIII. Each group (advanced, average, and retarded readers) was split into two sub-groups of which one was a reward sub-group and the other a control. The I.Q. range (determined by a verbal group test) was from 90 to 120.

All students individually attempted four visual-perceptual and cognitive tasks. Each student in the reward group was shown an array of small toys (miniature checkers, metal puzzles, toy automobiles, etc.) and told that if he did well on the tests he could have any one of these prizes. In summarizing their results the authors report that while reward

did not influence performance in a consistent manner, on most tasks it improved the performance of both advanced and retarded readers but had little effect on average readers.

This study was followed by another reported the succeeding year (Walters and Kosowski, 1963). There were again three groups of boys, selected as advanced, average, and retarded readers. Grade span was from VI to VIII, with twenty-four boys to each group. The I.Q. range was similar to that in the previous study. Also similar was the arrangement of the reading level into sub-groups of Reward and Control. Two tasks only were involved, both requiring the subject to identify into which of four compartments a small object had been placed. In the one test the correct compartment could be identified by a light signal, once the student had discovered for himself the colour which was associated with each compartment. Later the lights were disconnected and replaced by four signal tones communicated to the student through headphones. As in the earlier experiment, the reward groups were first shown an array of small manipulatables (miniature chess sets, key chains, pens, etc.) from which prizes they could choose one if they did well. In both experiments the non-reward students were tested before the reward students, and no student received his prize until all

testing was completed.

Walters and Kosowski reported that neither the performance of the advanced nor of the average readers was significantly affected by reward. On the other hand the performance of the retarded readers who were rewarded, was on the auditory task, significantly better than that of retarded readers who were not rewarded. In fact retarded readers who were rewarded on this task did as well as children in the other reading groups.

The author's comment (page 75):

> The data were interpreted as suggesting that retarded readers need an incentive in relatively difficult learning situations and also that unless highly motivated, retarded readers tend to be less attentive to stimuli.

V. MOTIVATIONAL REINFORCEMENT FOR CHILDREN

According to Ryans (quoted by Smith and Dechant, 1961, page 66) possible incentives for learning include rewards and punishments, praise and blame, group recognition, and knowledge of progress.

Rewards have been used in many experiments with children, and may be listed as manipulatables (as offered by Walters and Doan, and Walters and Kosowski), drinkables (which have been very little used), and edibles. Bijou and Sturges (1959) have reported on the kinds of positive reinforcers

used in a wide range of experiments with children. Pre-school children have been rewarded with raisins, currants, gumdrops, party mints, and candy bars, all with general success.

Older children (seven to twelve years) have responded to individually wrapped one-cent Hershey bars, and to jelly beans. Lindsley, working with deviant children (seven to fourteen years) is reported to have rewarded with a mixture of candies, including jelly-beans, corn-candies, gumdrops, sour-balls, peanuts, chiclets, small Hershey bars and Tootsie Rolls. Bijou and Sturges summarize by commenting that a large variety of edibles has been used effectively with children in both multiple-choice and free-operant tasks. The authors also point out several qualifying factors. Thus, one study (Warren and Brown) showed that differences in strength of appetite for candy influenced performance. Further, there is no doubt that different kinds of candy bars have differential appeal - the probable reason for the wide variety of candies used in some studies, (e.g. Lindsley). Another important consideration is the influence of the examiner. In a study carried out by Cantor and Hottel (quoted by Bijou and Sturges) each of the authors acted as the examiner for half of the subjects. When group performances were compared there

was a significant relationship between performance and the examiner concerned. It is apparent that when social reinforcement is not desired, all instructions should be kept to a minimum and given in a standardized form, preferably by a single examiner.

Summary of Positive Reinforcers for Children

The review made by Bijou and Sturges (1959) indicates that the form of motivational reinforcement most commonly used with children has been edibles in the form of cookies, candies or chocolate bars. Small toys have also proved successful as rewards, as, on a limited scale, have drinkables. To allow for individual preferences a choice of rewards is advisable.

It must be borne in mind that the attitude of the examiner may have greater influence on the students' performance than the rewards offered.

VI. SUMMARY OF THIS CHAPTER

This chapter has presented, through reviews of related research, support for the following assertions:

1. The majority of retarded readers are notably poor on tasks involving auditory memory.

2. Many retarded readers perform below the expected level for students of their age and I.Q. on tests of auditory memory span. This weakness has been most observable on tests of digits backwards, with digits forward and sentence memory also poor.
3. This poor memory does not appear to arise from an unusually rapid decay of the memory trace, but may be related to lack of attention, which in the case of visual memory has been shown to affect immediate recall.
4. Memory can be improved by increased motivation (reinforcement).
5. Children have worked better in many experimental situations for rewards of candy, drinks, or small prizes.
6. In two studies the prospect of reward caused retarded readers to significantly improve their performance.

CHAPTER III

EXPERIMENTAL DESIGN

In this chapter the design of the experiment is described, including the selection of the retarded and control groups, the tests and procedures employed, and the treatment of the data.

I. SELECTION OF THE SAMPLE

The total population available included all students attending schools of the Edmonton Separate School Board during May and June, 1966. To minimize the effects of differences in socio-economic backgrounds it was considered preferable to choose schools from the same or very similar areas of the city and, since a relatively high number of retarded readers was needed, higher socio-economic areas were ruled out. Edmonton schools which are situated in low-socio-economic areas include a high proportion of immigrant children among their students, so that results of auditory tests in English would be affected by the child's foreign language background. The schools chosen served a school population whose parents were largely of the skilled artisan class, upper working class, or lower middle class. All boys in

Grades IV, V, and VI were included so as to increase the population from which the sample was to be drawn, and because these particular grades seemed likely to offer students who, while knowing themselves to be poorer in reading than their fellows, would yet respond to the prospect of reward. The schools selected were St. Angelas and St. Mathews, with boys from the sixth grade at St. Alphonsus School also included. This sample population totalled:

Grade IV	107 boys
Grade V	105 boys
Grade VI	108 boys
Total	320 boys

Identification of Retarded Readers in the Sample

Results of standardized reading tests administered in the schools the previous fall, were compared with mental age as indicated in school records, and ninety-five students who seemed to show the greatest discrepancy between mental age and reading age, were selected for screening tests.

Screening Tests: Reading

Degree of retardation in reading is usually determined by comparing a child's achievement on a standardized test of reading with his apparent capacity as measured by an intelligence test. For the reading test in this study, it was

decided to use the Van Wagenen Unit Scales of Attainment (Reading Comprehension). The Mental Measurements Yearbook (Buros, 1940, page 1583), says of this test, "The Unit Scales of Attainment in Reading would seem in general to provide as valid measures of selected aspects of reading comprehension as any other test." Use of the test in this particular study was determined by the fact that it is the test used for yearly evaluation in the Public Schools of Edmonton, so that local norms are available for it. Since children in this study attended Separate Schools, the test was unfamiliar to them.

The reading age of each student was obtained by adding five years to the reading grade level achieved.

Screening Tests: Intelligence

Since the intelligence quotients shown in the school records were based on various tests administered at different age-levels, it was considered desirable to re-test the ninety-five students who appeared retarded in reading on the basis of school records. The test chosen for this purpose was the Lorge-Thorndike Non-Verbal Battery (Level Three, Form A). While admitting that, for the average child, the non-verbal battery will not predict achievement quite so well as scores based upon the verbal-battery, Lorge and Thorndike

(1962, page 3) contend that the non-verbal battery permits "an appraisal of abstract intelligence which is not influenced by specific disability in reading." The Fifth Mental Measurements Yearbook (Buros, 1959, page 350) describes the tests as well-designed, and comments that the uses recommended for them are reasonable and defensible. On this question of the measurement of retarded readers' intelligence by group tests, a study by Neville is pertinent. Neville (1965) compared the results obtained by groups of good, average and poor readers on a verbal group intelligence test, with their full-scale I.Q.'s as measured by the WISC. He found that while the average reader scores similarly on a verbal group intelligence test to his full-scale performance on the WISC, good readers do better on the verbal group test than their WISC I.Q.'s would indicate, while poor readers do worse on verbal group tests than on the WISC full-scale. Neville concluded (page 261) that, "Poor readers tended to make scores on group intelligence tests requiring reading, which were significantly lower than the scores made on individual tests requiring little or no reading."

Since it was not possible to give each child the WISC tests, it was decided to administer the non-verbal battery of the appropriate level of the Lorge-Thorndike Intelligence Test.

Following completion of the tests, students at each grade level were ranked according to the degree by which reading age fell below chronological age and mental age. (See Table I, page 48).

Selection of Control Group

Since the aim of the investigation was to contrast retarded readers with non-retarded, it was decided that the control group should be selected in such a way that it was representative of all the children in the sample. Therefore after numbering all boys in the sample, a table of random numbers (Keeping, 1962, page 413) was consulted, and fifteen students were selected at each grade level. The first ten of each group to pass the auditory and speech requirements constituted the control group.

Auditory Acuity and Speech Difficulties

Further reference was now made to each child's cumulative record card to determine whether an individual audiometer test had been successfully passed and whether any speech defects or problems of language background existed. Where necessary, individual audiometer tests were given. The names of several students were deleted from both retarded and control lists as a result of weaknesses, such as those mentioned

above, which might have confused the results of the study.

Retarded and Control Groups as Finally Constituted

A description of the group of retarded readers and the "average" group of readers is provided in the following tables. Table I shows the degree by which each retarded reader's reading age fell below his chronological age and mental age. In the process of selection, first any student was discarded, whose reading age was not at least one year below his mental age. The remaining students were then ranked according to the degree by which their reading age fell below their chronological age. In the case of ties, the discrepancy between reading age and mental age was used.

Table II relates to the control group, and since these students had not attempted the same screening tests as the retarded group, they were grouped into high, average, and low readers, on the basis of teachers' evaluations.

Every boy in the sub-group of severely retarded readers, Table IV, was reading more than two years below his mental age.

Table III summarizes the distribution of intelligence quotients, together with the mean, and median I.Q.'s. For the control group only verbal I.Q.'s were available (from the

TABLE I

RETARDED READERS: EXTENT OF RETARDATION WHEN READING AGE IS COMPARED WITH CHRONOLOGICAL AGE AND MENTAL AGE

Student Number	Years by which reading age falls below chronological age.	Years by which reading age falls below mental age
Grade IV		
* 1	-3.1	-6.9
2	-2.4	-5.6
3	-2.4	-1.9
4	-2.2	-3.0
5	-2.1	-6.2
* 6	-1.8	-3.0
7	-1.4	-1.9
* 8	-1.3	-1.0
9	-1.0	-2.4
10	-0.6	-3.0
Grade V		
11	-3.1	-3.7
12	-3.0	-1.8
13	-3.0	-1.1
14	-1.8	-6.5
*15	-1.8	-5.1
16	-1.7	-1.4
17	-1.6	-3.1
18	-1.5	-1.0
19	-1.3	-5.5
20	-1.1	-3.1
Grade VI		
21	-3.4	-2.6
22	-2.4	-1.1
23	-1.9	-6.8
24	-1.8	-6.4
*25	-1.8	-3.2
26	-1.1	-3.7
27	-0.9	-1.9
28	-0.7	-5.5
29	-0.6	-5.1
30	-0.2	-4.4
Mean	-1.8	-3.6
Median	-1.8	-3.5
Range	-0.2 to -3.4	-1.0 to -6.9

* The process of random selection caused these students to be chosen for the control group also.

TABLE II

CONTROL GROUP: READING ABILITY AS ASSESSED BY CLASS TEACHERS

Reading Ability Group	Number of students receiving this assessment
Top	8
Top Average	3
Average	10
Low Average	2
Low	7 *

* This number includes the five control-group members who are also in the retarded group.

school records); both verbal and non-verbal I.Q.'s are illustrated for the retarded readers.

During the analysis of the data, those students in the control group who had been classified by their teachers as top or top-average readers, were combined into a high control sub-group so that their performance might be compared with that of the total retarded group. Similarly the twelve most retarded readers made a low retarded group. Table IV shows the mean, median and range of intelligence quotients for the three groups, as established by a non-verbal group intelligence test for the retarded groups, and by a verbal group intelligence test for the high-control group. In view of the findings of Neville (1965) this was felt to provide a reasonable basis for comparison.

TABLE III

DISTRIBUTION OF INTELLIGENCE QUOTIENTS
WITHIN RETARDED AND CONTROL GROUPS

I.Q. Range	Retarded Group * Non-Verbal	Retarded Group ** Verbal	Control Group ** Verbal
76 - 80		1	
81 - 85			
86 - 90		2	3
91 - 95	2	6	2
96 - 100	6	2	
101 - 105	4	8	9
106 - 110	5	3	4
111 - 115	4	5	5
116 - 120	5		4
121 - 125	3	2	2
126 - 130	1	1	
131 - 135			
136 - 140			1
Median	108.	103.	106.
Mean	108.9	103.8	107.9
Range	92 to 128	77 to 130	87 to 139
Standard Deviations	9.5	11.2	11.2

* Non-Verbal I.Q. as measured by the Lorge-Thorndike Non-verbal Battery, given by the investigator.

** Verbal I.Q. as measured by a standardized group instrument, results taken from school records.

TABLE IV

NONVERBAL I.Q.'S OF TOTAL RETARDED READERS, AND LOW SUB-GROUP OF RETARDED READERS, COMPARED WITH VERBAL I.Q.'S OF HIGH SUB-GROUP OF THE CONTROL

Group	Median I.Q.	Mean I.Q.	Range
Total retarded group (30 S's)	108	108.9	92 - 128
Low retarded group (12 S's)	113	112.7	98 - 122
High control sub-group (12 S's)	113	114.9	101 - 139

II. TESTS OF AUDITORY MEMORY

Auditory Digit Span

As described in the previous chapter, there is a considerable body of research indicating that poor readers have difficulty with tests of digit span. Since many of these earlier studies used the appropriate sub-test from the Wechsler Intelligence Scale for Children, it was decided to use this WISC digit span test for the present investigation. Since there is also evidence that retarded readers find backward digits particularly difficult, it was determined to separate the scores of the WISC digit span sub-tests into Digits Forward and Digits Backwards, as well as presenting

the total score as Digits Combined. Further, as discussed in a later section of this chapter, the normal method of scoring by length of span, would be augmented by a "unit" score.

The WISC subtest of digits forward begins with a series of three digits, followed by four digits, five digits, and so on to nine digits. Two trials are allowed at each level. The test of digits backward is similar but ranges from two to eight digits.

In the forward test the subject repeats the digit-series after the examiner, while in the backward test the subject has to reverse the order of the digits as he repeats them.

The digits-combined score is simply the sum of the two sub-scores.

Syllable and Sentence Memory

In the learning stages the reading process consists of recalling the speech sound which is associated with a particular visual stimulus. If the word is not recognized as a whole, the reader must hold in his mind the sequence of individual phonemes or groups of phonemes as he recalls them, until he is able to blend them into one word-whole. As Vernon observes, (1957), page 45), "Much evidence goes to show that difficulties frequently arise in remembering the

exact order of sounds in a word and in blending unitary sounds to form whole words."

Further, as the learner-reader translates each visual pattern into its spoken word, he must retain this word-sequence until the whole sentence is read and understood. Hence the choice of the syllable and sentence memory tests for use in this study.

The Syllable Memory Test

The investigator had difficulty in finding a suitable standardized test of syllable-memory. Kromann (1959) reported the Gates Memory for Nonsense Syllables too difficult for both good and poor readers, and indeed the test is not included in the 1947 or subsequent editions of Gates Tests. Other syllable-tests employ words, which it was felt might introduce subjective associations which could affect results. The investigator accordingly compiled the syllable memory test used in this study. (See Appendix). Base words for the test were those used in the Gates Word Pronunciation Test, Form 1, (Gates, 1947, page 606). All syllables occurring in this test were listed, and arranged in sequences consisting of three pairs of syllables, followed by three groups of three syllables, then three groups of four, three groups of five and finally three groups of six syllables. Syllables

were arranged in such a manner that while no actual words were formed, the sequences were similar to those encountered in words. Thus, syllables or word parts which most commonly occur at the end of words (e.g., -dy, -ery, -ful) were so placed.

While widespread validation of the measure was not possible, experience on the pilot study indicated that it did distinguish between students, and provided a range of increasing difficulty.

Items were read at a rate of one per second using natural inflection, and the subject repeated each syllable-series in the same form and order used by the examiner. Testing stopped when the subject had given a total of three lines of syllables incorrectly.

The Sentence Memory Test

Several standardized tests include sub-tests of auditory memory for sentences. Thus, Reid (1962), in a study with Grade I children, reported a significant correlation between results from four reading tests and the sentence memory test of the Betts measures of reading readiness. A test containing sentences rather more suitable for older students was employed by Sandstedt (1964) and was selected for use in the present study. This particular measure is taken from the

Detroit Tests of Learning Aptitude (1959 revision). Referred to by its compilers as "Auditory Attention Span for Related Syllables" the test consists of forty-three sentences ranging in length from six to twenty-seven syllables. The subject repeats each sentence after the examiner, until errors are made on two successive occasions. A copy of this test is included in the Appendix.

III. THE PILOT STUDY

When test items are to be presented orally, the examiner must ensure that his manner of speaking does not impair the effectiveness of the measures. The problem here is not only one of clarity, but more particularly of emphasis. Thus, when digits are spoken at an even rate, it is still possible for the examiner to group them into more easily remembered sub-groups by the rise and fall of his voice. Accordingly, to test proposed measures and procedures, a pilot study was carried out with fifteen Grade V boys. The need for the examiner to keep his voice at a relatively constant pitch during the digit-span test was noted during this pilot performance. Further, for the test of sentence memory, speed of delivery and intonation patterns were varied, and the results noted. In general, the faster the material was read,

and the more natural the grouping into phrases, the more easily the material was recalled. Consequently, in the main study, the investigator read at a moderate pace, with less modulation of voice and fewer pauses than is customary in oral reading, but avoiding a flat, word by word rendition.

Because of the variations in procedures introduced during the pilot study, the results will not be included in this paper; however, some of the changes for which the pilot study was responsible may be of interest. These included:

(i) Finding the best rate and style of delivery for each measure, which separated out the students without making the tests artificially difficult. Thus the need to avoid grouping digits by the rise and fall of the voice was noted, and an optimum manner of reading sentences was developed.

(ii) Finding the point on the sentence memory test at which most students were likely to begin to make errors, (for these students, at number twelve). Since this is a long test it is not desirable to test a large number of simple sentences.

(iii) The realization that tape-recording of responses was essential in the syllable and sentence tests.

(iv) Changing the wording of the instructions to render them more meaningful to the children.

IV. PROCEDURES DURING TESTING

Initial Testing - Neutral Conditions

Each student was tested by the investigator in a room apart from his fellows, in the school at which he normally attended. Each child was greeted by the examiner in the same manner and asked three questions to help place him at his ease. During the testing he was addressed by his name on all occasions.

The tests were given in the following order: digits forward, digits backwards, syllables, and sentences. No acknowledgement of the correctness or otherwise of responses was made, until the completion of testing when each subject was thanked and told that he had done well. Time taken for the battery of tests averaged between ten and fifteen minutes.

Errors made during testing were noted by the examiner on individual test-sheets in such a way that marking could not be observed by the subject. Responses were also recorded on magnetic tape.

Second Testing - Reward Conditions

Approximately two weeks after the initial testing, the

tests were re-administered. As on the first occasion, each subject met individually with the examiner in a room of the school which he normally attended. The pupil was reminded of the previous testing and informed that he was going to be told how well he had performed on that earlier occasion. He was told he was going to be given the tests again, and if he did better this time than he had done previously, he would win a candy bar. At this point the lid was lifted from a box containing some thirty assorted five cent candy bars.

In front of the student was placed a board measuring fifteen inches by twenty-six inches laid out as a race track, with several lanes for the contestants. (See Fig. 1). The lanes were marked-off into sections, each of which contained the number of the lane. Thus Lane 1 was broken into a succession of blocks each numbered 'I'. A series of holes had been drilled in the track, so that one hole occurred in each section. These holes were numbered consecutively.

The student was told that Lane 1 represented Test 1, Lane 11 represented Test 11, and Lane 111 stood for the Test 111. Digits Forward and Digits Backward were treated as one test for this situation. The student was now shown a flag labelled 'WIN I'. Special simplified scores had been calculated from the first testing, which told the student only the

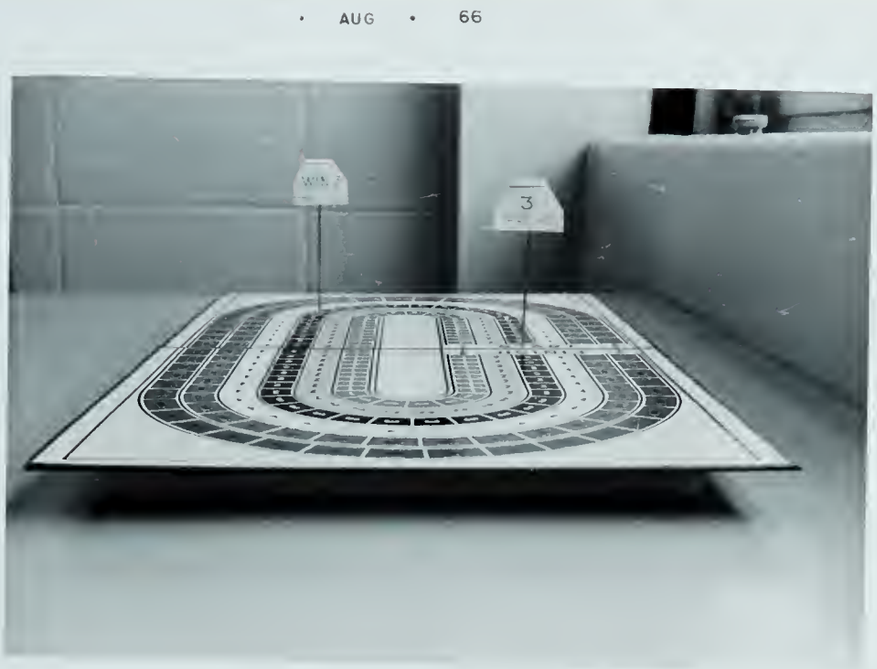

FIGURE I

APPARATUS USED IN THE REWARD SITUATION, TO KEEP STUDENT INFORMED OF HIS PROGRESS.

number of complete lines he had read correctly. If the subject had scored six correct lines on Test 1 he was told this, and the 'WIN 1' flag was set up in hole #6 of Track 1. Thus, the student could see how far around the track he had progressed on the first attempt at Test 1. He was now given another flag with which to mark his progress on his present attempt. Beginning with the flag on the start line, the student moved the flag forward one hole along the track each time he gave an answer correctly - as confirmed by the examiner. In this way the student constantly had before him the level of his own achievement and could see how close he was getting to equalling or surpassing his previous performance. After the first test was completed, those flags were removed from the board and, if the student had "won" (i.e. beaten his previous performance), the flags were placed alongside him, otherwise elsewhere on the table. Two new flags were now introduced for Test 11 and later for Test 111. Of the sixty students thus tested, all but two improved on at least one of the three tests. These two students were led to believe that their responses on the final test were correct, so that they too "won". The examiner encouraged students during the testing, and when each student completed his testing he took the candy bar of his choice. The effectiveness of this reinforcement

is discussed in Chapter V.

V. PROCEDURES USED IN SCORING

Digit Span Tests

As indicated in the definitions given in Chapter I, two separate scoring systems were applied to the digit span tests. The span score for digits was obtained in the manner recommended by Wechsler, namely, the subject was credited with the number of digits in the longest span of digits correctly recalled. However, under this system a subject who fails in his first attempt at any given span is given a second series of digits to try, and testing stops only when the subject fails on two successive attempts. Thus, it is possible for a student who makes a number of errors, and who requires two attempts at each series, to achieve the same span-score as a student who is correct on his first attempt at each span. Further, under this scoring system a subject may, on a subsequent performance of the test, make significantly fewer errors without improving his span score. Therefore, in an effort to secure a more responsive system of scoring it was decided to treat every digit as a unit. Since, as indicated, two series are available for each span, a span of three digits would be equalled by six units; a span of four digits would be equalled

by fourteen units, (that is, eight units from the "four-span" plus six units from the "three-span"). If a student repeated a span correctly at the first attempt he would be credited with also reading correctly the second span of that length. Any errors would be deducted from the total units attempted or credited. The score thus obtained is the Span Score. An imaginary example may serve to illustrate:

Stimulus	Response	(Errors indicated by /)
958	958	
482	*	* No attempt required. Credited under Unit Score
6172	6217	
5496	5496	
75249	7524/	
83245	8245	

Span Score = 4.

Unit Score = 24 - 6 = 18. (i.e. Total units attempted or credited, minus total errors made.)

Both span and unit scores are reported in Chapter IV.

Syllable Test

Only one scoring system was employed on this test, yielding a combined span-and-unit score based on the last three all-correct lines. It will be recalled that the syllables were arranged first in pairs, then in threes, fours, fives and sixes. There were three lines of syllables at each span-length and testing stopped after a total of three lines

was incorrectly repeated by the subject. The subject's score was therefore determined by totalling the number of syllables in the last three lines recalled correctly.

Scoring the Sentence Memory Test

The method of scoring used in the Sentence Memory Test was that suggested by the authors, (Baker and Leland, 1935), in which the subject is credited with the number of syllables occurring in the last sentence read correctly.

VI. RECORDING OF ERRORS

If poor auditory memory is a factor in reading disability, it would seem that on tests of auditory memory retarded readers may differ from good readers in the type of error which they most commonly commit. Therefore, on each of the four auditory tests a record was kept of errors made, under the categories Additions, Omissions, Substitutions and Transpositions. It was felt, however, that the frequency of an error (i.e. the number of separate occasions on which a specific type of error is made) is more significant than the total number of errors made of that type. Thus, for a boy to omit one item on three separate occasions, would seem more significant than the fact that on one occasion he made three omissions in one sentence. The actual number of additions or

omissions made to one sentence is largely contingent upon the structure of that particular sentence, but if a certain error shows a marked tendency to recur on various separate occasions it would appear to be worthy of consideration. Accordingly, on each test trial given, the occurrence of a certain type of error was recorded with a 'I' regardless of whether one or several items were omitted, substituted, etc.. The total count of errors thus recorded is referred to as the error frequency.

VII. TREATMENT OF THE DATA

Raw scores of all students were punched on data cards and processed by computer. Means and standard deviations were obtained for the total group of retarded readers and a sub-group of severely retarded pupils. Similarly means and standard deviations for the total control group and sub-group of the best readers within the control group were also obtained.

By the use of appropriate programmes with the computer, means were compared between groups, and between the neutral and reward testing situations for each group. For each difference in means the value was obtained and compared with a table of significant values. The probability of the differences occurring randomly was also calculated.

To determine the contribution of intelligence to differences of performance occurring between the total retarded group and the high control sub-group, an analysis of covariance was carried out using a multiple regression programme with the computer.

An analysis was made, and the t-test for differences in percentages was applied, to determine the significance of observed differences in error-frequency as between retarded and average readers.

VIII. SUMMARY OF CHAPTER III

This chapter has described the manner in which this investigation was designed and carried out. How the sample of retarded readers and the matching control group were selected has been indicated, together with a description of the auditory tests chosen for use. Some indications of the lessons learned from the pilot study have been given, and the procedures employed in the neutral and reward situations have been enlarged upon. Finally, the methods used in scoring the tests have been detailed, together with the statistical tests to be applied to determine the significance of the data.

Results of the data analysis are given in Chapter IV.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF THE DATA

In this chapter the data gathered in order to test the experimental hypotheses, are analyzed and interpreted. The data are presented in the following sequence: first, a comparison between the scores of the total groups, as they performed on the auditory memory tests in the neutral situation; next, a similar comparison between the total groups in the reward situation; and third, an analysis and comparison of the gains made by each group, from the neutral to the reward situation.

Following these comparisons of the total groups, the mean auditory memory scores of a high control and a low retarded subgroup, are examined and contrasted.

The number of individual students from each group, whose scores changed in the reward situation is presented and discussed, and finally an analysis is made of the types of errors committed and the frequency of their occurrence.

Each analysis of the data begins with a general description of the results obtained, and indicates apparent differences in mean scores of the groups concerned. The degree of significance of such observed differences, is discussed in

the second part of each analysis.

I. ANALYSIS AND COMPARISON OF GROUP SCORES

Neutral Situation: Observed differences between means of total groups

A comparison of the mean scores of the retarded group and the control group, on each of the auditory measures, is illustrated in Figure 2. Mean scores of the retarded group are shown as a proportion of the control group scores, with the latter equated with one hundred.

The first three vertical bars on Figure 2 relate to the tests of digits forward, digits backwards, and digits combined, in terms of span scores. The retarded readers performed less well than the control group on the tests of digits forward, but equalled the span score of the control group on the test of digits backward. When digit-scores were combined, the retarded readers did less well than the control students.

The same tests are represented again in Figure 2 by the last three vertical bars, which illustrate the unit scores. While confirming the general relationship between the two groups indicated by the span scores, the unit scores show that the degree by which the control students out-performed the retarded readers as measured by the span score

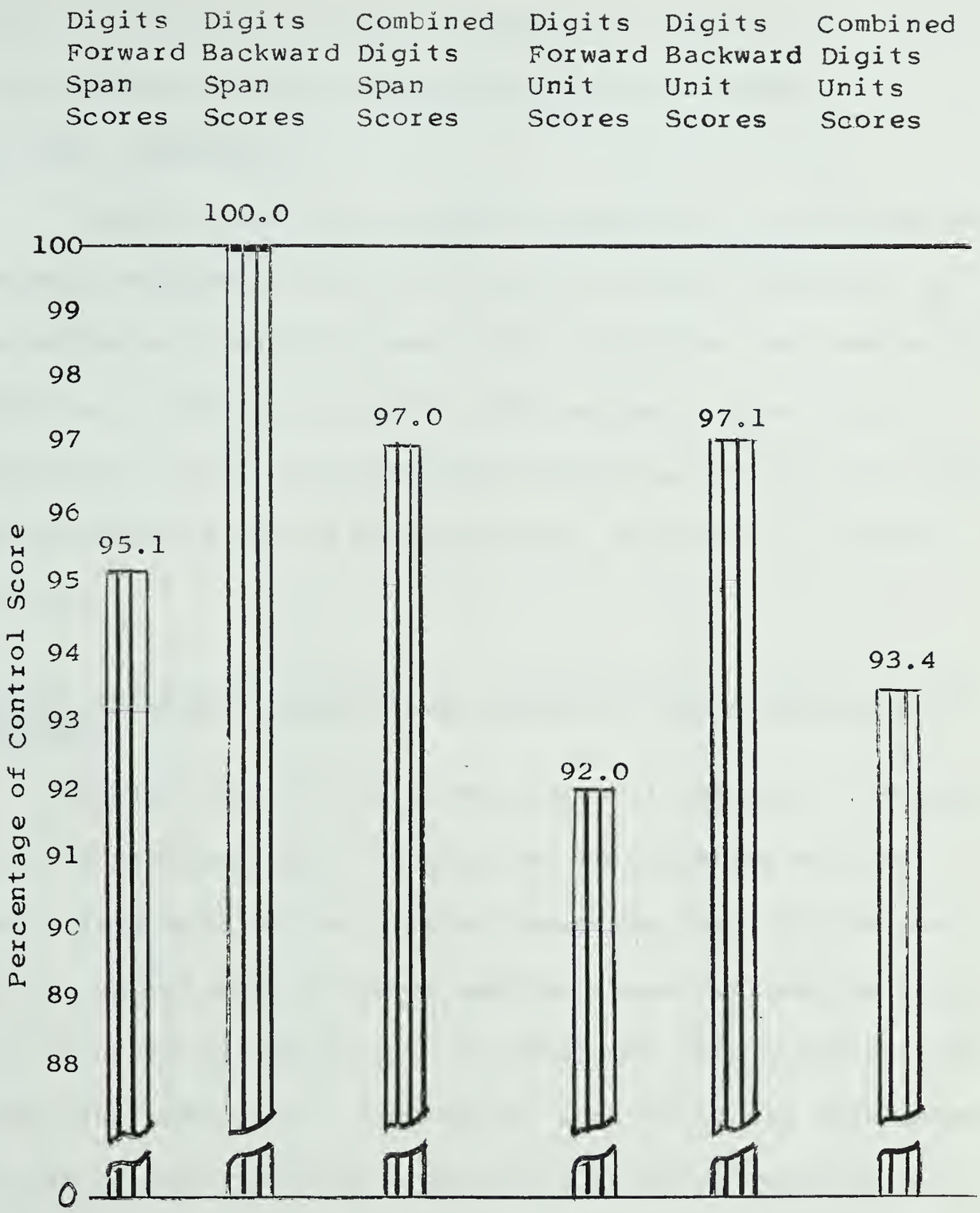

FIGURE 2

NEUTRAL SITUATION: MEAN SCORES OF RETARDED READERS AS A PROPORTION OF CONTROL GROUP SCORES, ON DIGIT TESTS (CONTROL SCORES=100)

method, is greater than first revealed, and that the retarded readers failed to do as well as the control group on any of the digit measures.

Figure 3 provides a similar comparison of the retarded readers' performance with that of the control students, on the subtests of auditory memory for syllables, and sentences. With the control group scores represented by a hundred, it again appears that the retarded readers failed to equal their fellow students of the control group, on either of the two measures.

Neutral Situation: Statistical significance of observed differences

While seven of the eight scores illustrated in Figures 2 and 3, indicate that the group of retarded readers performed less well on the auditory measures than did the control group, it must be asked whether these differences could have occurred accidentally. To determine this question, the t-test for independent samples was applied to the mean scores. Results of this test are supplied in Table V, together with the standard deviations, obtained values of t, and the probability levels.

Reference to Table V shows that the critical ratios for the differences in means, vary from 0.306 to 1.402.

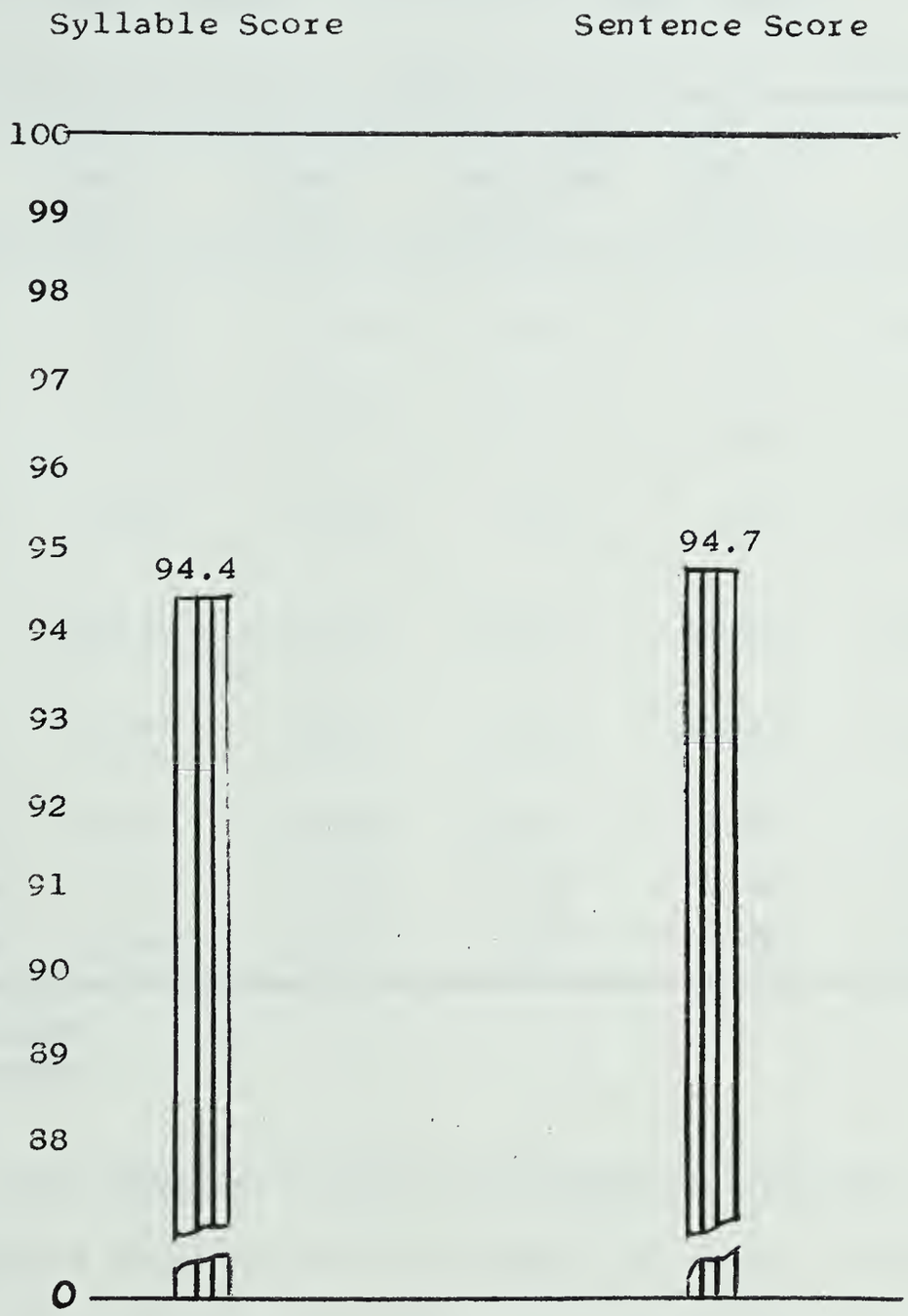

FIGURE 3

NEUTRAL SITUATION: MEAN SCORES OF RETARDED READERS' AS A PERCENTAGE OF CONTROL GROUP SCORES, ON SYLLABLE AND SENTENCE TESTS (CONTROL SCORES=100)

TABLE V

NEUTRAL SITUATION: COMPARISON OF MEAN SCORES OF RETARDED READERS WITH CONTROL GROUP MEANS

Test	Retarded Group Mean	Control Group Mean	Std. Dev. Retarded Group	Std. Dev. Control Group	t	p
Digits *Forward	5.17	5.43	1.07	1.12	0.920	.36
Digits *Backward	3.50	3.50	0.76	1.20	0.000	
Digits *Combined	8.67	8.93	1.30	1.79	0.650	.52
Digits **Forward	32.40	35.23	13.10	13.84	0.801	.43
Digits **Backward	17.87	18.60	6.61	11.33	0.306	.76
Digits **Combined	50.27	53.83	14.90	19.97	0.771	.44
Syllables	9.00	9.53	1.93	1.96	1.043	.30
Sentences	13.00	13.73	1.97	2.02	1.402	.17

* Span scores
** Unit Scores

Since for the combined groups the degrees of freedom = 58, t has a critical value at the .05 level, of 2.000. Thus, in statistical terms, none of the differences in mean scores can be considered significant. The likelihood of the observed differences occurring by chance is indicated by p, so that on the initial testing in the neutral situation, the test which

showed the difference between mean scores most nearly significant, was that of sentence memory, with $p = .17$. However, this still does not equal the level of .05 (usually accepted as confirming a significant difference).

Reward Situation: Analysis and comparison of group scores

Mean scores obtained by the two groups in the reward situation are presented in the same manner as the neutral scores. Figure 4, page 73, indicates the relative value of the retarded reader scores, when the control group scores are equated with a hundred.

Beginning with the span scores, it is noticeable that the retarded group came very close to equalling the control group on the test of digits forward. Next best performance for the retarded group was on the combined-digits score, with memory for digits backwards the poorest of their achievements, as measured by the span scores. Unit scores follow the same pattern, but emphasize the apparent differences.

Results of the reward performances on the tests of syllables and sentences, are shown in Figure 5, and again a discrepancy appears between the mean scores of the two groups, with the control "average" group of readers doing better than the retarded reader group. Together, Figures 4 and 5 show that in the reward situation the retarded group failed to

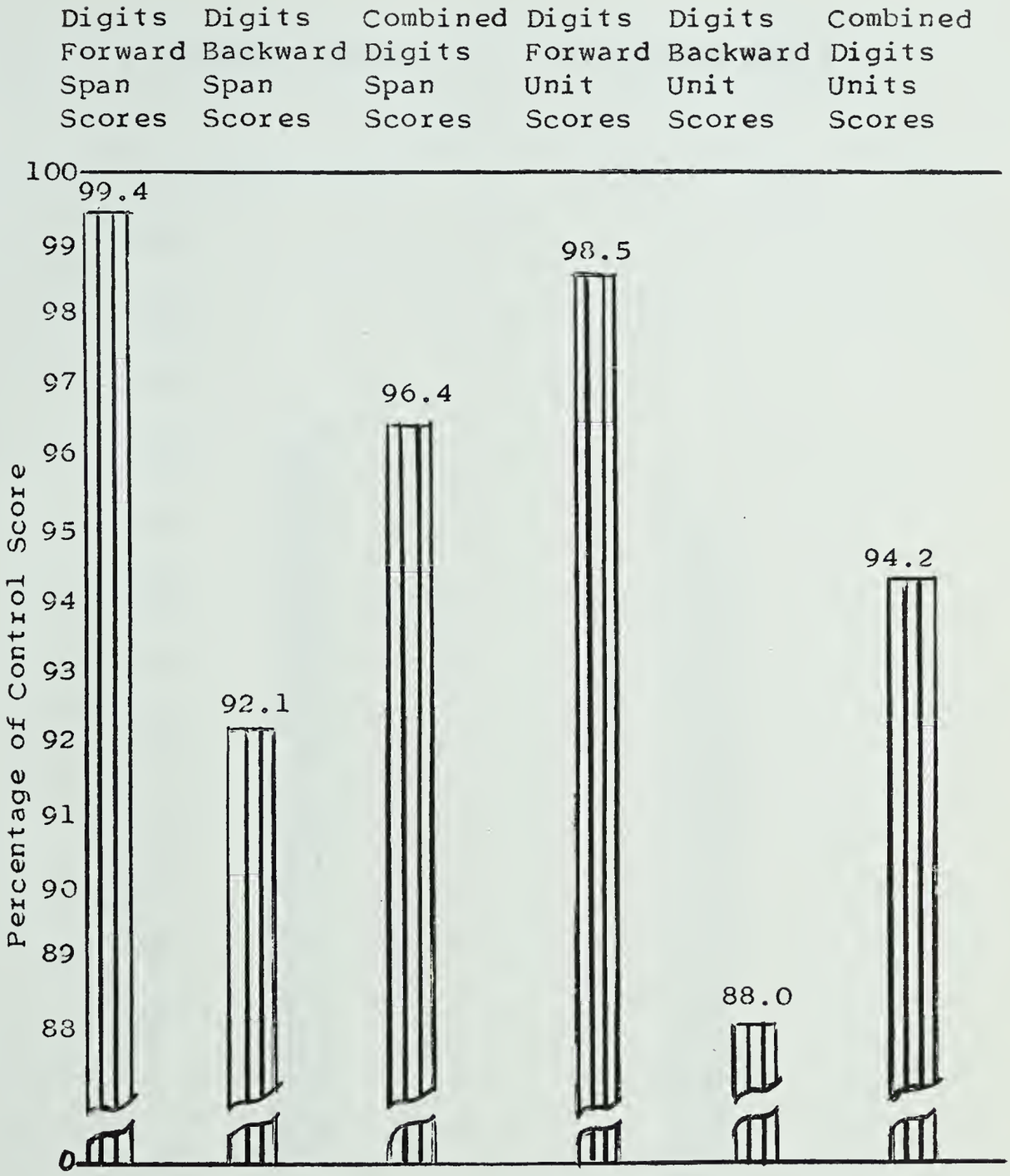

FIGURE 4

REWARD SITUATION: MEAN SCORES OF RETARDED READERS AS A PROPORTION OF CONTROL GROUP SCORES, ON DIGIT TESTS (CONTROL SCORES=100)

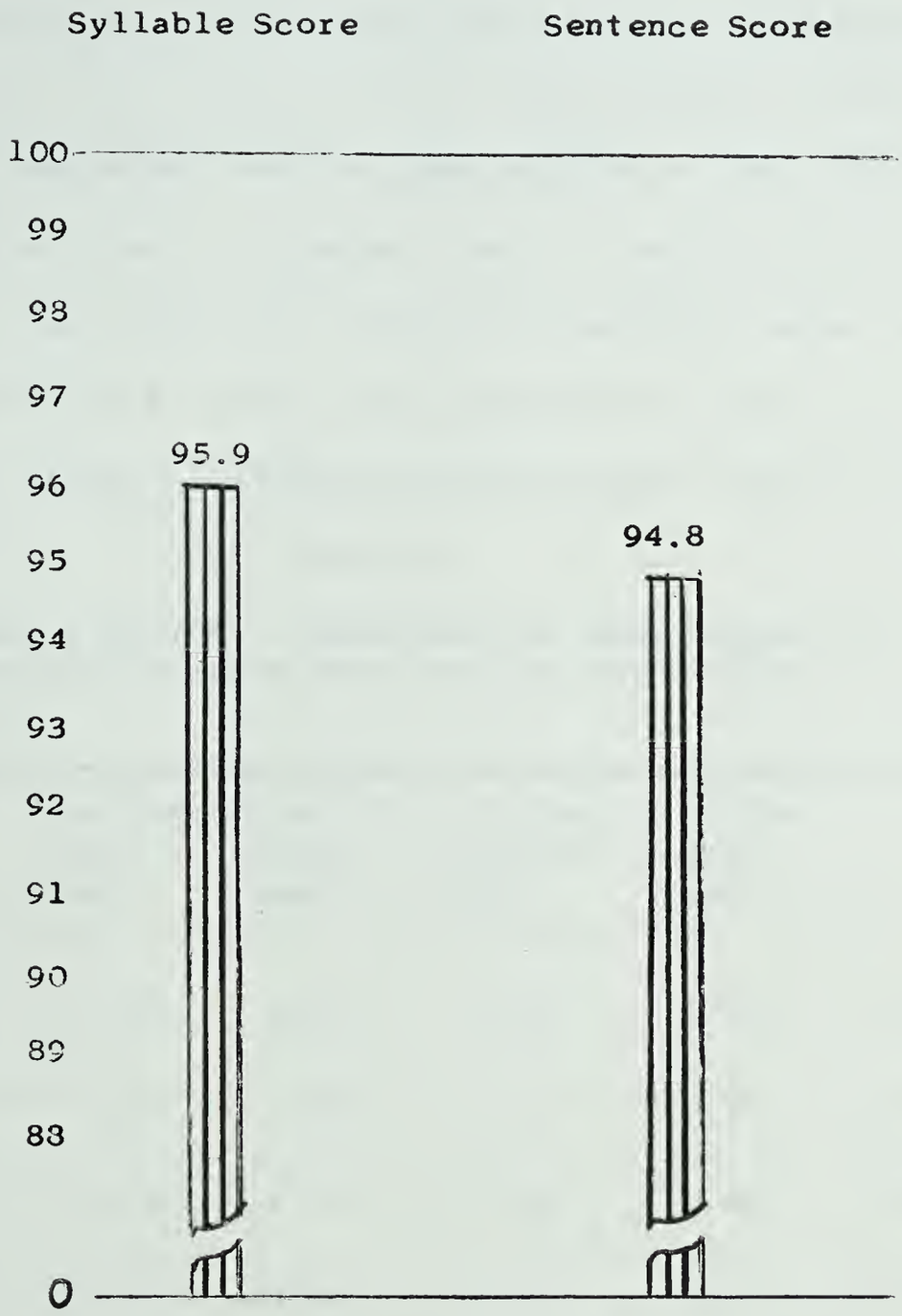

FIGURE 5

REWARD SITUATION: MEAN SCORES OF RETARDED READERS AS A PERCENTAGE OF CONTROL GROUP SCORES, SYLLABLE AND SENTENCE TESTS. (CONTROL SCORES=100)

equal the control group on any of the eight scores reported.

Reward Situation: Statistical significance of differences

The t-test to measure the significance of differences between independent samples, was applied to the differences in performance noted on Figures 4 and 5. Results of the t-test, including mean scores on each of the auditory measures, standard deviations, t-values, and probability levels, appear in Table VI. Again, although each mean score reported for the

TABLE VI

REWARD SITUATION: COMPARISON OF MEAN SCORES OF RETARDED READERS WITH CONTROL GROUP MEANS

Test	Retarded Group Mean	Control Group Mean	Std. Dev. Retarded Group	Std. Dev. Control Group	t	p
Digits *Forward	5.43	5.47	1.02	1.23	0.112	0.36
Digits *Backward	3.50	3.80	0.92	0.91	1.248	0.22
Digits *Combined	8.93	9.27	1.48	1.69	0.798	0.43
Digits **Forward	36.30	37.13	12.95	15.44	0.224	0.82
Digits **Backward	18.27	20.77	8.81	9.72	1.026	0.31
Digits **Combined	54.53	57.90	16.80	20.99	0.674	0.50
Syllables	9.37	9.77	2.17	1.84	0.758	0.45
Sentences	13.47	14.20	1.84	2.47	1.283	0.20

* Span Score
** Unit Score

retarded group falls below the corresponding mean for the control group, the differences are not significant at the .05 level of confidence. The probability levels are lowest for the tests of sentence memory and memory for digits backwards, where the likelihood of the differences shown occurring accidentally, is twenty-two in a hundred, and twenty in a hundred, respectively.

Summary of comparisons between mean scores

Mean scores obtained by each group on the various measures, were compared for the neutral and reward situations. While the control group out-performed the retarded readers on seven of the eight scores in the neutral situation, and on all eight scores in the reward situation, none of the observed differences proved to be statistically significant at the .05 level of confidence. Lowest probability of random occurrence of the differences observed in the neutral situation was for sentences, $p = .17$, and in the reward situation for measures of digits backwards, $p = .22$, and sentences, $p = .20$.

II. ANALYSIS AND COMPARISON OF GAINS

Since it was postulated that retarded readers would make a greater response to the prospect of reward than would good readers, the amount of gain made by the groups on each

measure, was next examined. Answers were sought to two questions: 1) Did either group perform significantly better in the reward situation than it did in the neutral situation? 2) Did one group improve more than the other, on the auditory measures?

Improvement from neutral to reward situations: Statistical significance of gains

To determine whether the reward situation had produced any increases in mean scores which could be stated as significant, the t-test for correlated samples was applied. The obtained results, together with mean scores and standard deviations, are summarized in Table VII for the retarded readers, and Table VIII for the control group.

While none of the differences reaches the .05 level of significance, several of the gains are such as would only occur accidentally between five and ten times in each hundred testings. For the retarded readers, the changes in unit scores for digits-forward and digits-combined, fall close to the .05 level of significance; while, as Table VIII shows, the control group unit and span scores for combined digits are close to the same level, with span scores for digits backwards falling nearer to the .10 level. The control group also made a gain in mean sentence memory score, which falls in the .05

TABLE VII

SIGNIFICANCE OF GAINS MADE BY RETARDED READERS WHEN REWARD SCORES ARE COMPARED WITH NEUTRAL SCORES

Test	Neutral Mean Scores	Reward Mean Scores	Neutral Standard Deviation	Reward Standard Deviation	t-value
Digits *Forward	5.17	5.43	1.07	1.02	1.246
Digits *Backward	3.50	3.50	0.76	0.92	0.000
Digits *Combined	8.67	8.93	1.30	1.48	1.161
Digits **Forward	32.40	36.30	13.10	12.95	1.609++
Digits **Backward	17.87	18.27	6.61	8.81	0.315
Digits **Combined	50.27	54.53	14.90	16.80	1.647++
Syllables	9.00	9.37	1.93	2.17	1.076
Sentences	13.00	13.47	1.97	1.84	1.249

* Span Scores.
** Unit Scores.
++ Significant between .05 and 0.10 levels of confidence.
Critical values of t: at .10 level, t = 1.311
at .05 level, t = 1.699

TABLE VIII

SIGNIFICANCE OF GAINS MADE BY CONTROL GROUP WHEN REWARD SCORES ARE COMPARED WITH NEUTRAL SCORES

Test	Neutral Mean Scores	Reward Mean Scores	Neutral Standard Deviation	Reward Standard Deviation	t-value
Digits *Forward	5.43	5.47	1.12	1.23	0.162
Digits *Backward	3.50	3.80	1.20	0.91	1.469++
Digits *Combined	8.93	9.27	1.79	1.69	1.355++
Digits **Forward	35.23	37.13	13.84	15.33	0.833
Digits **Backward	18.60	20.77	11.33	9.72	1.271
Digits **Combined	53.83	57.90	19.97	20.99	1.694++
Syllables	9.53	9.77	1.96	1.84	0.815
Sentences	13.73	14.20	2.02	2.47	1.544++

* Span Scores.
** Unit Scores.
++ Significant between .05 and 0.10 levels of confidence.
Critical values of t: at .10 level, t = 1.311
at .05 level, t = 1.699

to .10 range of confidence. Perhaps the most noteworthy comparison emerging from Tables VII and VIII, is that while both groups show a significant gain in mean score for digits combined, (at approximately the .05 level), the digit test most contributing to this gain, is for the retarded readers the test of digits forward, but for the control group the test of digits backwards.

Gains made by retarded readers compared with control group gains

To enable a comparison to be made between the relative gains of each group, these gains were translated into percentages of the group's neutral scores. In this form the gains are presented in Figures 6 and 7.

Of the digit span tests, the span scores indicate that the retarded readers apparently made considerably greater gains than the control group on the test of digits forward, but failed to increase their score on digits backwards, on which test the control group made a large increase in score. When compared on digits-combined score, both groups show very similar gains. The unit scores confirm the differences in improvement between the two groups, indicated by their span scores: retarded readers sizeably improved their forward digit score, but failed to match a very large increase in

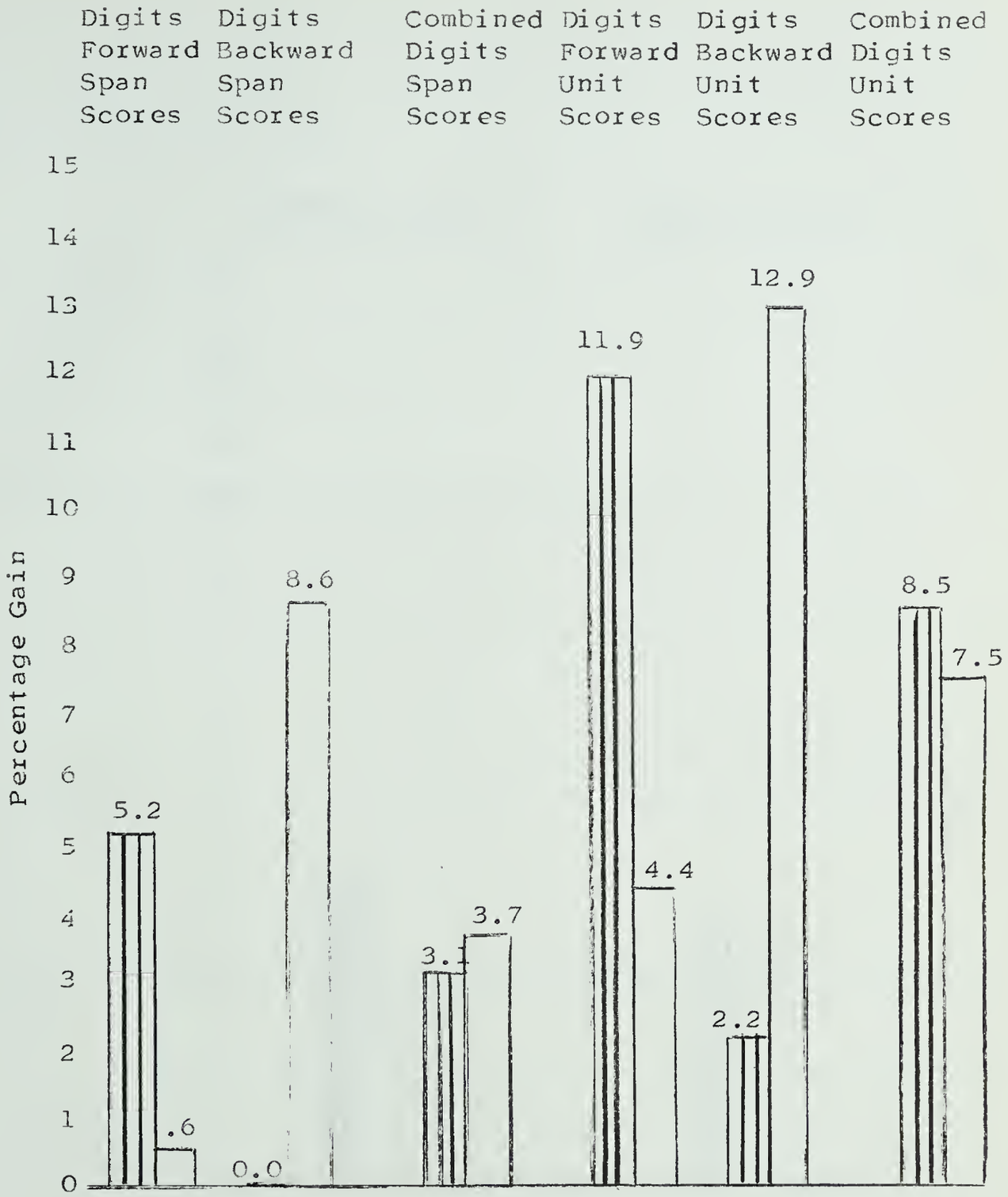

FIGURE 6

PERCENTAGE OF INCREASE IN MEAN SCORES FOR DIGITS, FROM NEUTRAL TO REWARD SITUATIONS

= Percentage Gain by Retarded Group.

= Percentage Gain by Control Group.

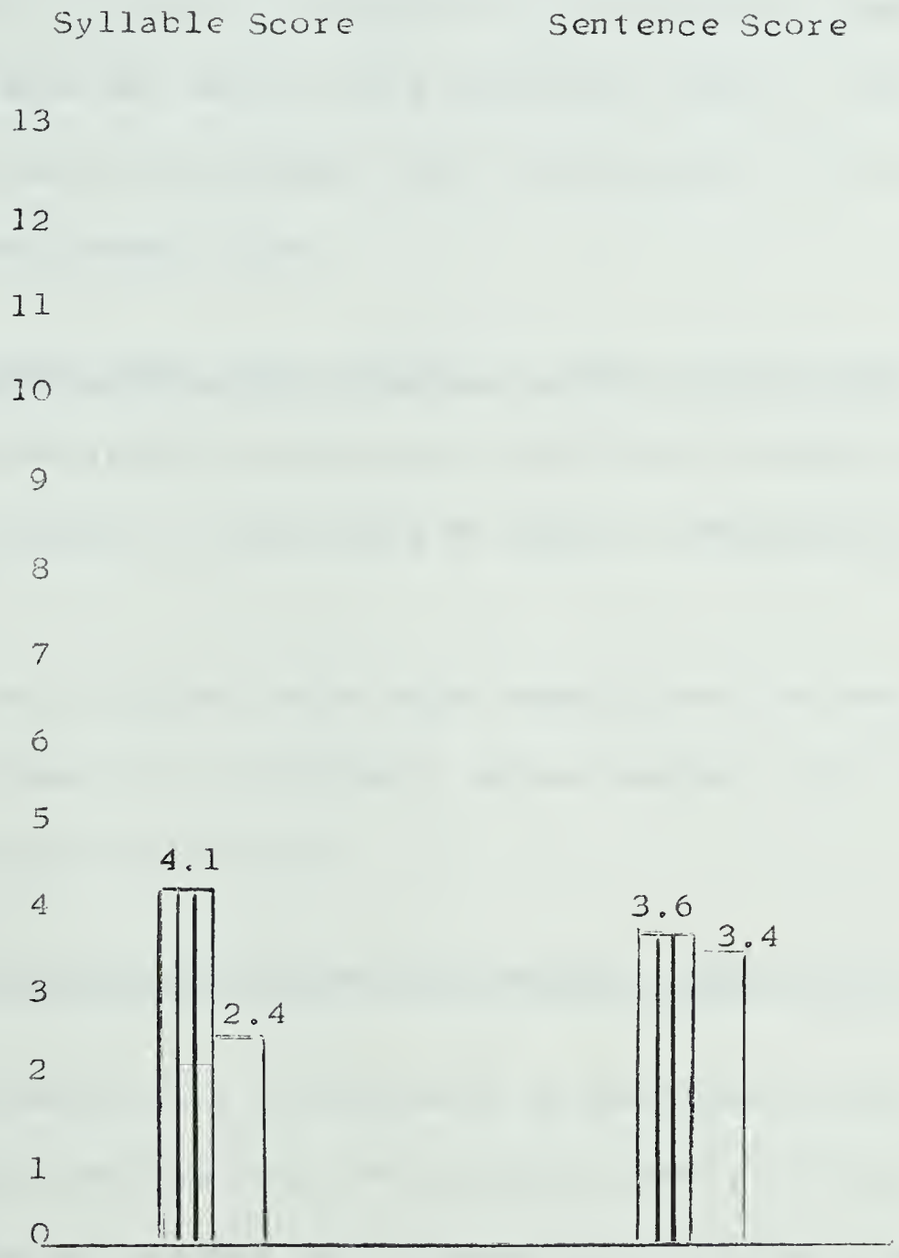

FIGURE 7

PERCENTAGE OF INCREASE IN MEAN SCORES, FOR SYLLABLES AND SENTENCES, FROM NEUTRAL TO REWARD SITUATIONS

= Percentage gain by Retarded Group.

= Percentage gain by Control Group.

digits backward scores by the control group. Again, both groups showed similar improvement when the digits-combined scores were compared.

Figure 7, page 82, reveals that on syllable memory the greater increase was made by the retarded readers, with similar proportionate improvement being registered by both groups on the sentence memory test.

Summary of gains made from neutral to reward situations

Retarded readers made gains significant between the .05 and .10 levels of confidence on digits combined and digits forward.

The control group made gains significant between the .05 and .10 levels of confidence, on sentences, digits combined, and digits backwards.

Summary of comparisons between the relative gains of the two groups

Retarded readers made greater proportionate gains than control readers on the tests of syllable memory and digits forward. Control readers made greater proportionate gains on digits backwards. Both groups made similar proportionate gains on digits-combined and sentence scores.

None of the differences in gains between the groups, was significant at the .05 level.

III. COMPARISONS OF TOTAL GROUPS WITH SUB-GROUPS

From the analysis of the data thus far presented, certain differences in the score-patterns of the two groups emerged. It was therefore determined to attempt confirmation of these trends by selecting sub-groups of the most superior, and most retarded readers. From each grade level the four most advanced readers were selected and formed into a twelve-student group, designated the high control sub-group. A group of the twelve most retarded readers was similarly formed, and referred to as the low retarded sub-group.

The initial comparisons, illustrated in Figures 8 - 11, match the mean scores of the total retarded group with those of the total control group, and the high control sub-group. For purposes of illustration, the retarded readers' scores are indicated as percentages.

Neutral Situation

Figure 8 shows that while the retarded group's score for digits forward was ninety-five per cent of the total control group's, it was only ninety-one per cent of the high control mean score. Similarly, the backward digit score of the retarded readers equalled the total control group's score, but represented only eight-nine per cent of the high control

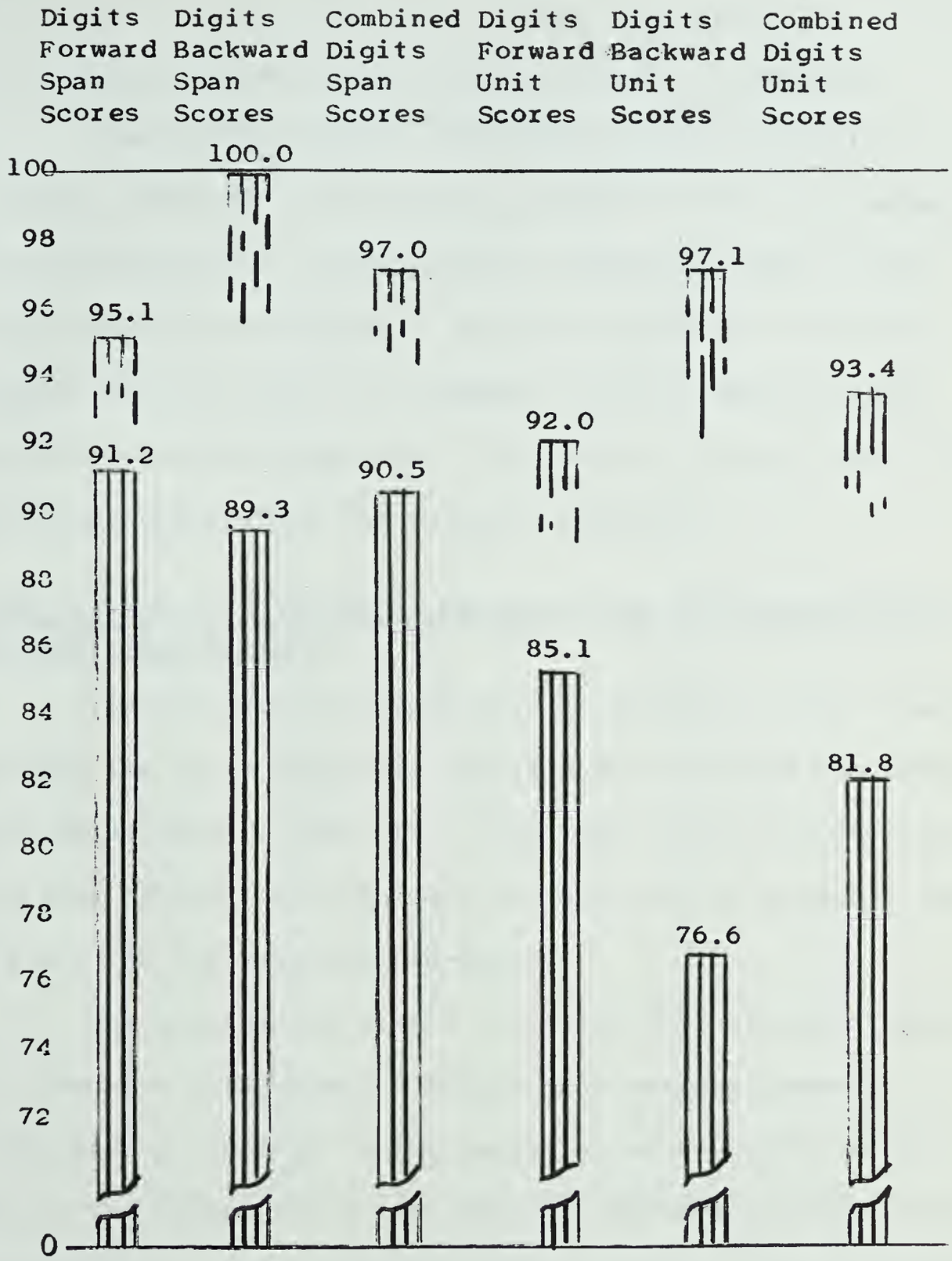

FIGURE 8

NEUTRAL SITUATION: DIGIT SCORES OF RETARDED READERS, AS A PERCENTAGE OF HIGH CONTROL SUB-GROUP SCORES

(High control sub-group scores = 100. Broken lines show percentage which retarded readers' score was of entire control group's score.)

sub-group's. Less noticeable changes are observable in Figure 9, where sentence and syllable scores are compared.

Thus of the neutral situation it may be said that, contrasting retarded readers with superior readers, increased the differences in score-patterns observable when the two total groups were compared. Most noticeable is the much greater gap in scores for backwards digits, where the retarded group score represents only seventy-six per cent of the score obtained by the superior readers.

Significance of differences between total and sub-groups in the neutral situation

The differences illustrated in Figures 7 and 8, were checked for their degree of significance, and the resulting data summarized in Table IX. This table also includes comparisons between the high control sub-group of superior readers and the low retarded sub-group.

The greater difference resulting when retarded readers are compared with superior rather than average readers, is confirmed by the fall in the levels of probability, which indicate the likelihood of the reported differences occurring accidentally. Thus, when the total retarded group is compared with the high control sub-group, the probability levels for the differences in means are, for sentences $p = .13$, for

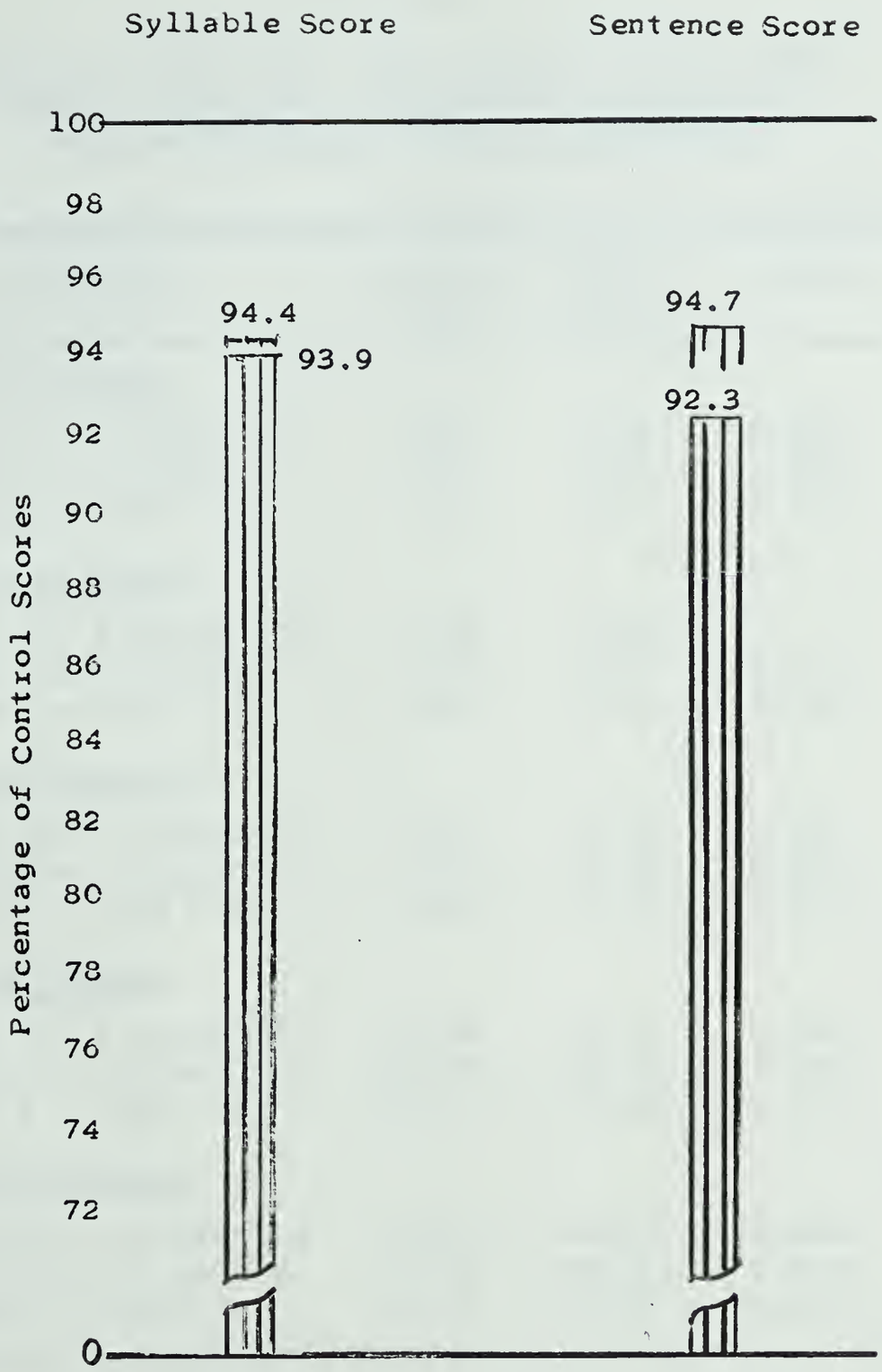

FIGURE 9

NEUTRAL SITUATION: SYLLABLE AND SENTENCE SCORES OF RETARDED READERS, AS A PERCENTAGE OF HIGH CONTROL SUB-GROUP SCORES

(High control sub-group scores = 100. Broken lines show percentage which retarded reader score was of entire control group's score.)

TABLE IX

NEUTRAL SITUATION: COMPARISONS BETWEEN TOTAL GROUPS, TOTAL RETARDED VERSUS HIGH CONTROL, AND LOW RETARDED VERSUS HIGH CONTROL

Test and groups being compared	Retarded Mean	Control Mean	t-value	p-level
*Digits Forward				
Total R's v Total C's	5.17	5.43	0.930	.36
Total R's v High C's	5.17	5.67	1.325	.19
Low R's v High C's	5.17	5.67	1.274	.22
*Digits Backward				
Total R's v Total C's	3.50	3.50		
Total R's v High C's	3.50	3.92	1.132	.19
Low R's v High C's	3.33	3.92	1.156	.26
*Digits Combined				
Total R's v Total C's	8.67	8.93	0.650	.52
Total R's v High C's	8.67	9.58	1.652	.11
Low R's v High C's	8.50	9.58	1.510	.14
**Digits Forward				
Total R's v Total C's	32.40	35.23	0.801	.43
Total R's v High C's	32.40	38.08	1.219	.23
Low R's v High C's	31.83	38.08	1.245	.23
**Digits Backward				
Total R's v Total C's	17.87	18.60	0.306	.76
Total R's v High C's	17.87	23.33	1.604	.12
Low R's v High C's	16.67	23.33	1.414	.17

Table IX - (continued)

Test and groups being compared	Retarded Mean	Control Mean	t-value	p-level
**Digits Combined				
Total R's v Total C's	50.27	53.83	0.771	.44
Total R's v High C's	50.27	61.42	1.801	.08
Low R's v High C's	48.50	61.42	1.686	.11
Syllables				
Total R's v Total C's	9.00	9.53	1.043	.30
Total R's v High C's	9.00	9.58	0.916	.36
Low R's v High C's	9.17	9.58	0.587	.56
Sentences				
Total R's v Total C's	13.00	13.73	1.402	.17
Total R's v High C's	13.00	14.08	1.543	.13
Low R's v High C's	13.67	14.08	.500	.62

* Span Scores
** Unit Scores

digits forward p = .23, for digits backwards p = 12, and for digits combined p = .08.

Comparison of the mean scores shows that the severely retarded readers in the neutral situation, did less well than the total retarded group on the measures of digits forward and digits backward. Severely retarded readers did better than the total retarded group on the syllable and sentence memory tests. Because of the much smaller number of students

involved when the two sub-groups are compared with one another, changes in means are not always accompanied by observable changes in the p-value.

Neutral Situation: Summary of comparisons between total groups and sub-groups

Means for the superior readers were higher than total control group means on all tests, but on syllables the difference was very small. When t-values were calculated, the score most significantly differentiating between superior and retarded readers was that of digits combined, $p = .08$, with backward digits ($p = .12$) contributing most to this difference.

Severely retarded readers appeared to do less well than the total retarded group on digits combined, with slightly lower scores on forward digits and notably lower scores on digits backwards.

Reward Situation: Total groups compared with sub-groups

Figures 10 and 11, relating to scores obtained on the reward testing, again indicate that while the retarded group scored lower than the average group of readers, they scored much lower than the sub-group of superior readers. This increased difference is observable on all the measures, with the gap between readers and non-readers being widest on the test of digits backwards, unit scores.

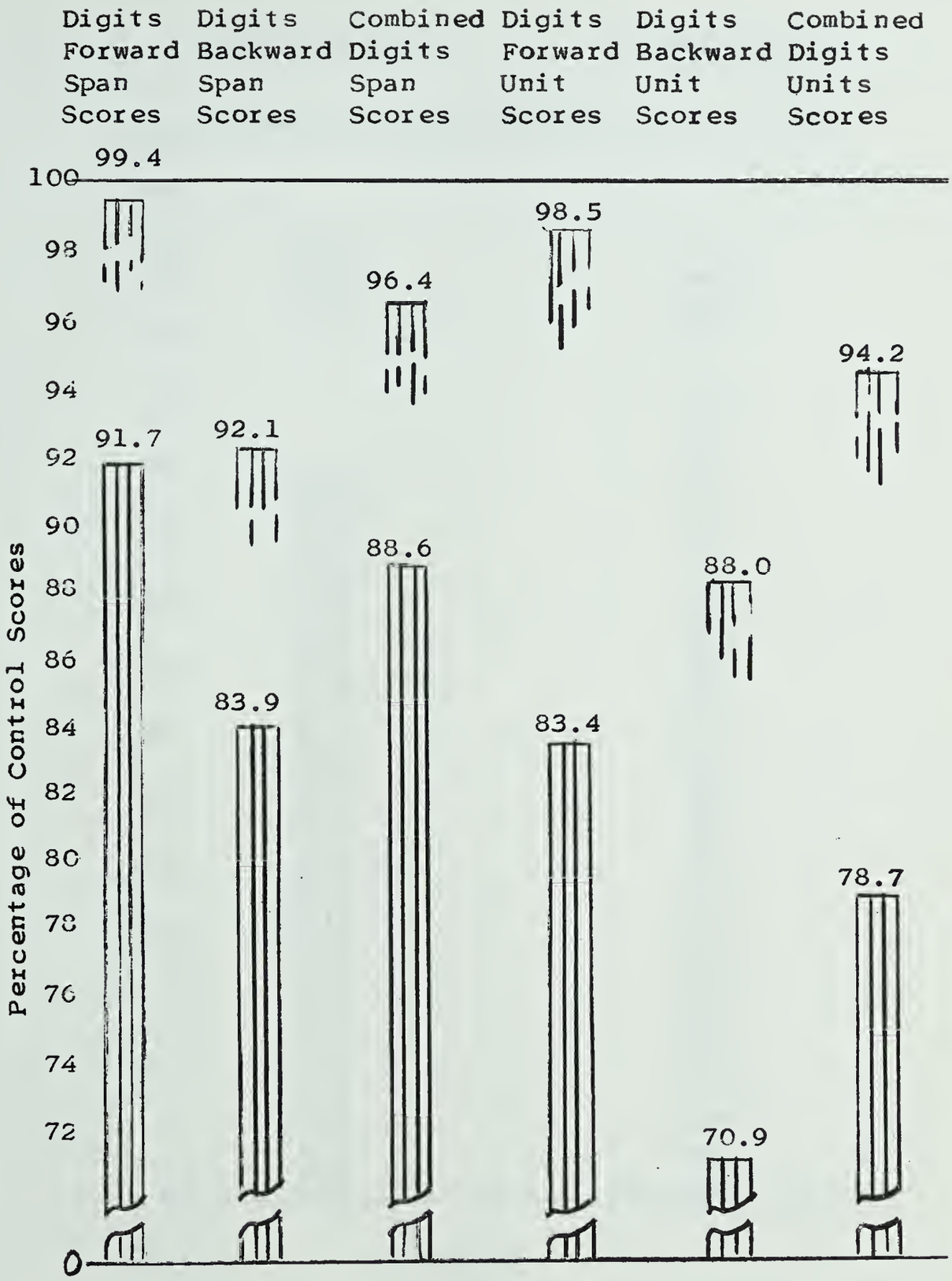

FIGURE 10

REWARD SITUATION: DIGIT SCORES OF RETARDED READERS, AS A PERCENTAGE OF HIGH CONTROL SUB-GROUP SCORES

(High control sub-group score = 100. Broken lines show percentage which retarded reader score was of entire control group's score.)

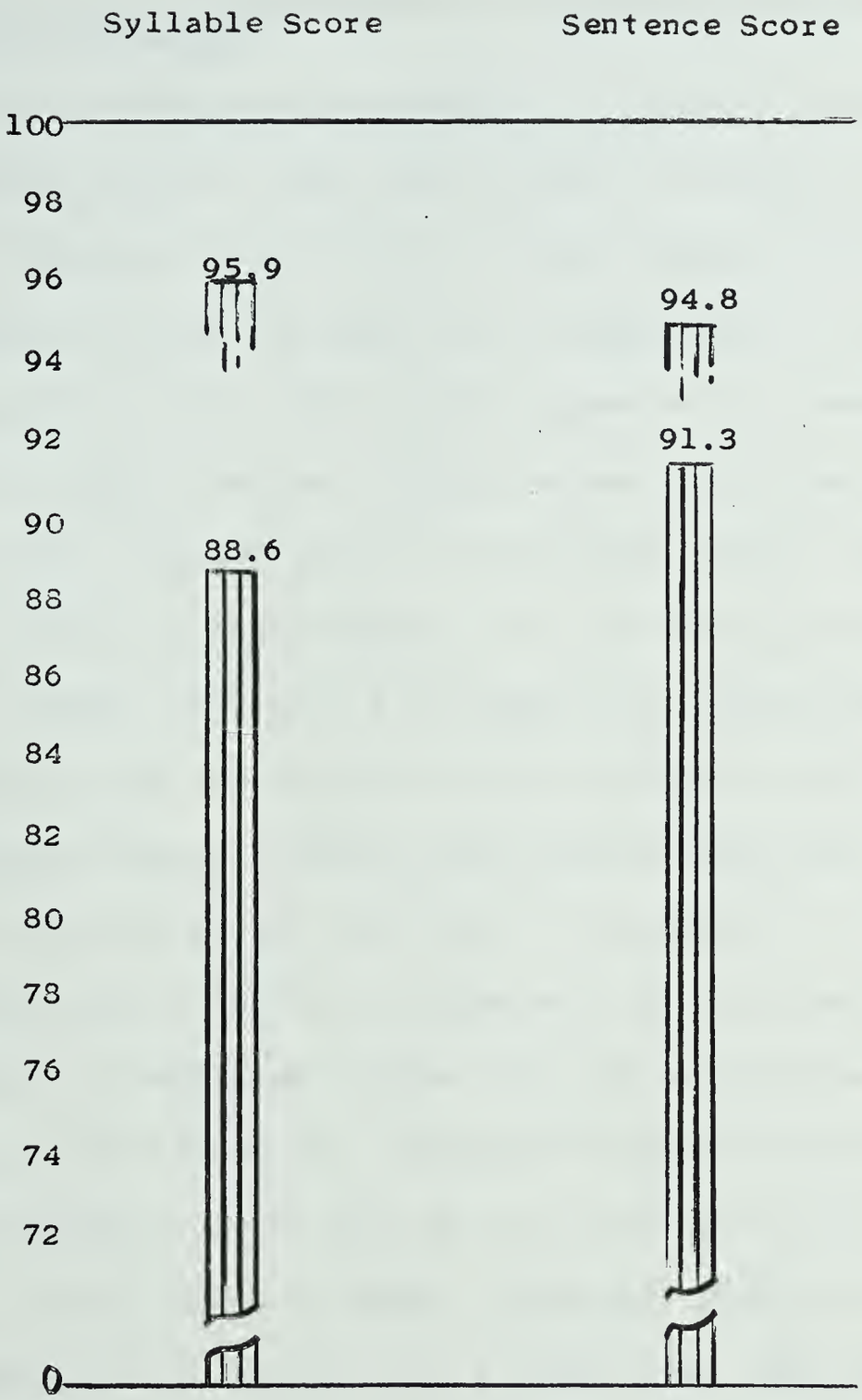

FIGURE 11

REWARD SITUATION: SYLLABLE AND SENTENCE SCORES OF RETARDED READERS, AS A PERCENTAGE OF HIGH CONTROL SUB-GROUP SCORES

(High control sub-group score = 100. Broken lines show percentage which retarded reader score was of entire control group's score.)

Reward Situation: Significance of differences between total groups and sub-groups

The disparities illustrated in Figures 10 and 11 are confirmed by Table X, which lists means, t-values, and p-levels. The pattern is similar to that observed in the neutral situation, with the mean for the high control sub-group exceeding that of the total control group on all measures. Again, the digits combined subtest scores most clearly separate the total retarded group from the high control sub-group. This difference is significant at the .05 level on both span and unit scores. Further, it is again the digits backward scores which most contribute to this difference, with the total retarded group scoring significantly below the high control sub-group at the .05 level of confidence. It is particularly notable that this difference is sustained when the comparison is restricted to the high control and low retarded sub-groups, confirming that severely retarded readers score lower on backward digits than do the total group of retarded readers. On all other measures, including digits forward, the severely retarded group has a higher mean than the total retarded group. Indeed the mean of the severely retarded readers on the digits forward test, appears higher than the mean for the total control group.

TABLE X

REWARD SITUATION: COMPARISONS BETWEEN TOTAL GROUPS, TOTAL RETARDED VERSUS HIGH CONTROL, AND LOW RETARDED VERSUS HIGH CONTROL

Test and groups being compared	Retarded Mean	Control Mean	t-value	p-level
Digits Forward				
*Total R's v Total C's	5.43	5.47	0.112	.36
*Total R's v High C's	5.43	5.92	1.345	.19
*Low R's v High C's	5.58	5.92	0.860	.40
Digits Backward				
*Total R's v Total C's	3.50	3.80	1.248	.22
*Total R's v High C's	3.50	4.17	1.972	.05++
*Low R's v High C's	3.33	4.17	2.026	.05++
Digits Combined				
*Total R's v Total C's	8.93	9.27	0.798	.43
*Total R's v High C's	8.93	10.08	2.042	.05++
*Low R's v High C's	8.92	10.08	1.604	.12
Digits Forward				
**Total R's v Total C's	36.30	37.13	0.224	.82
**Total R's v High C's	36.30	43.50	1.541	.13
**Low R's v High C's	38.33	43.50	0.948	.35
Digits Backward				
**Total R's v Total C's	18.27	20.77	1.026	.31
**Total R's v High C's	18.27	25.75	2.190	.03++
**Low R's v High C's	16.75	25.75	2.106	.05++

Table X - (continued)

Test and groups being compared	Retarded Mean	Control Mean	t-value	p-level
Digits Combined				
Total R's v Total C's	54.53	57.90	0.674	.50
Total R's v High C's	54.53	69.25	2.199	.03++
Low R's v Low C's	55.08	69.25	1.576	.13
Syllables				
Total R's v Total C's	9.37	9.77	0.758	.45
Total R's v High C's	9.37	10.58	1.689	.10
Low R's v High C's	9.42	10.58	1.482	.15
Sentences				
Total R's v Total C's	13.47	14.20	1.283	.20
Total R's v High C's	13.47	14.75	1.716	.09
Low R's v High C's	13.67	14.75	1.105	.28

* Span Scores.
** Unit Scores.
++ Differences significant at or below the .05 level.

One other observation should be made concerning the digits forward results. Comparison of unit scores on Table IX with Table X confirms the great improvement made by the retarded reader group as a whole, on the reward situation. Thus when total groups are compared, the probability levels for the difference in forward digit scores rises from $p = .43$ in the neutral situation, to $p = .82$ in the reward situation, indicating a very small difference between the means of the

groups in the reward situation.

Sentences and syllables yield differences significant at the .09 and .10 levels, when the retarded readers are compared with the high control sub-group, but since severely retarded readers did slightly better than their total group on both these tests, the levels of significance of the differences, fell to .15 and .28 when the sub-groups are compared.

Summary of significant differences between sub-groups and total groups, in neutral and reward situations

The data previously described, indicates significant differences between retarded and control readers on the following tests.

Neutral Situation. The total retarded group scored lower than the high control sub-group, on the test of digits combined, with $p = .08$ for the difference in span scores. Contributing to this difference was a lower score on digits backwards, significant at the level of $p = .12$. Severely retarded readers in this study scored lower on digits backwards than did the total retarded group.

Reward Situation. The mean scores of the total retarded group were lower than those of the high control sub-group on the digits combined test, as measured by span and unit scores. The differences were significant at the .05 level. Again,

most contributing to this difference were the scores for digits backwards, where the differences between groups was also significant at the .05 level of confidence. The difference in the forward digits scores of the two groups, was not significant at the .05 level, nor were the differences in scores for syllables and sentences.

Total retarded reader group compared with the high control sub-group for differences in I.Q.

Table IV, page 51, indicates that there is a greater difference between the mean I.Q. of the retarded readers and the mean I.Q. of the high control sub-group, than exists between the two total groups. It seemed possible therefore, that the differences in mean scores for digits backwards and digits combined, might be attributable to the differences in I.Q. To determine this question, an analysis of covariance was undertaken, and the correlations found between I.Q. and digit scores, were compared with the correlations between digits scores and a combination of I.Q. + group membership, (i.e. level of reading ability). Correlations, F-ratios, and p-values are given in Table XI.

The fall in the levels of correlation, when the student's reading ability is ignored, is significant at levels from .05 to .07. This was taken as confirmation that the

observed differences in group scores for digits backwards and digits combined, were not caused by differences in I.Q.

TABLE XI

SIGNIFICANCE OF CORRELATIONS BETWEEN DIGIT SCORES AND I.Q., OR DIGIT SCORES AND I.Q. + READING ABILITY

Test score	R of *I.Q. + Reading Group	R of *I.Q. alone	F-ratio	p-value of difference
Digits Backwards (Span)	.298	.091	3.44	.07
Digits Combined (Span)	.309	.121	3.52	.07
Digits Backwards (Unit)	.333	.149	3.90	.05
Digits Combined (Unit)	.339	.171	3.80	.06

* Non-verbal I.Q. for retarded readers, verbal I.Q. for control.

IV. FREQUENCY OF IMPROVEMENT AMONG RETARDED AND CONTROL STUDENTS

Earlier, pages 80 to 83, a comparison was made of the relative gains of each group from the neutral to the reward situation, to determine whether retarded readers respond better to the prospect of reward than do average readers. Regardless however of the total gains made by a group, it may be asked how many individuals in that group improved or worsened, when the reward element was introduced. Accordingly, a

comparison was made of the scores obtained by each individual in the neutral and reward situations. The types of changes occurring were totalled for each group and the results presented in Tables XII and VIII. Changes occurring on the individual measures are summarized in Table XII, and total changes on all measures indicated in Table VIII.

Frequency of improvement shown by retarded readers compared with that of the control group

When the frequency of improvement shown by the group of retarded readers, on each of the auditory measures, was compared with the frequency of improvement exhibited by members of the control group, none of the differences were significant at the .05 level of confidence. What follows is therefore only descriptive of observed rather than significant differences.

The results of the digits tests appear to reflect the same changes in numbers of students improving as they do in the amount of improvement. Thus the digits-combined results confirm that more than half of the students in each group, improved on their second performance of the digit-tests. However, more control readers improved than retarded readers, a point most clearly shown by the unit scores. Furthermore, this greater improvement on the digits combined scores,

TABLE XII

NUMBER OF STUDENTS IN EACH GROUP CHANGING THEIR LEVEL OF PERFORMANCE FROM THE NEUTRAL TO THE REWARD SITUATION

Digits Forward	Span Scores		Unit Scores	
Type of change	Retarded/Control		Retarded/Control	
Improved	12	11	20	21
Same	13	11	2	0
Worse	5	8	8	9
Digits Backward	**Span Scores**		**Unit Scores**	
Type of change	Retarded/Control		Retarded/Control	
Improved	6	10	11	14
Same	19	14	5	4
Worse	5	6	14	12
Digits Combined	**Span Scores**		**Unit Scores**	
Type of change	Retarded/Control		Retarded/Control	
Improved	15	15	17	20
Same	6	9	1	1
Worse	9	6	12	9
Syllables				
Type of Change	Retarded/Control			
Improved	14	12		
Same	7	11		
Worse	9	7		
Sentences				
Type of change	Retarded/Control			
Improved	13	12		
Same	10	14		
Worse	7	4		

originates in the digits backward test, where more control students showed improvement. On the digits forward test, the frequency of improvement is similar for both groups, but slightly favours the retarded readers.

On the syllable and sentence memory tests, retarded readers have slightly more students scoring higher, but also more students scoring lower.

When reference is made to Table XIII, it is evident that the total number of students showing improvement was identical for each group: twenty-seven out of thirty. The total number of scores showing improvement was also similar for the two groups: from totals of 120 scores, 58 retarded scores, and 59 control scores showed improvement. Table XIV presents a similar summary of the students who made lower scores on their second testing. Twenty-three retarded readers made a total of thirty-seven lower scores, while twenty-one control readers returned thirty-two lower scores. Here the advantage is with the control group.

Summary of score changes observable in the reward situation

The total number of students and scores showing improvement in each group is almost identical, however the retarded group had a slightly higher proportion of students with lower scores, and also a higher proportion of lower scores.

TABLE XIII

TOTAL NUMBER OF STUDENTS AND SCORES SHOWING IMPROVEMENT IN EACH GROUP FROM NEUTRAL TO REWARD SITUATION

Degree of improvement	Retarded Students	Retarded Scores	Control Students	Control Scores
Improved on 1 test only	9	9	7	7
Improved on 2 tests only	7	14	11	22
Improved on 3 tests only	9	27	6	18
Improved on 4 tests	2	8	3	12
Total students showing improvement	27		27	
Total scores showing improvement		58		59

TABLE XIV

TOTAL NUMBER OF STUDENTS AND SCORES SHOWING DETERIORATION IN EACH GROUP

Degree of Deterioration	Retarded Students	Retarded Scores	Control Students	Control Scores
Lower score on 1 test only	11	11	11	11
Lower score on 2 tests only	11	22	9	18
Lower score on 3 tests only	0	0	1	3
Lower score on 4 tests	1	4	0	0
Total Students with lower scores	23		.21	
Total lower scores		37		.32

Data for the above tables based on the tests of digits forward, digits backwards, syllables and sentences.

Of interest was the high proportion of all students whose digits-combined scores changed. In contributing to this change, the digits forward test showed slightly more retarded than control readers showing improvement, while more control group students improved on the test of digits backwards. There was little to choose between the groups on the number of changes occurring in syllable and sentence test scores.

As previously stated, none of the observed differences was significant at the .05 level.

V. ANALYSIS AND COMPARISON OF THE MOST COMMONLY RECURRING ERRORS OF RETARDED AND CONTROL READERS

If the performance of retarded readers, on tests of auditory memory, differs significantly from that of average readers, this difference may result from a tendency on the part of the retarded reader to fall into a particular form of error. An analysis was therefore made of the errors committed by all students participating in this study. As described previously, this analysis was based on the number of separate lines of digits, syllables or words in which a particular error was made, and does not relate to the total number of individual items omitted, added, substituted or transposed.

The data is summarized in Table XV.

It must be stated that when t-values were calculated for the observed differences in error-frequency, none were significant at the .05 level. The table nevertheless exhibits certain discernable trends.

Digits Forward

The "best error" to be expected here, is perhaps the transposition error, and this is in fact the error most commonly made by both groups. It is noticeable that this type of error increases in occurrence from forty-three per cent, to fifty-two per cent, for the retarded group, with reductions in other types of error. This increase in the number of "best error" accompanies the much improved scores of the retarded group on this particular test.

Digits Backward

On this test the retarded readers made notably more errors of transposition than did the control group. This may not however be the same type of transposition error as occurs in the other auditory tests. On those other tests the error consists of unintentionally changing the position of the item; here however the student is required to transpose the items, and in doing so the retarded reader confuses their order.

TABLE XV

FREQUENCY OF SPECIFIC ERRORS AS A PERCENTAGE OF TOTAL ERRORS: COMPARISON OF RETARDED, CONTROL AND HIGH-CONTROL GROUPS

Tests and Groups	Additions		Ommissions		Substitutions		Transpositions	
Digits Forward	N.	R.	N.	R.	N.	R.	N.	R.
Retarded	4.8	2.9	32.7	30.4	20.2	14.8	43.1	52.0
Control	9.1	1.0	26.4	25.5	14.5	17.9	50.0	55.7
High Control	10.2	0.0	26.5	30.2	8.2	18.6	55.1	55.2
Digits Backward								
Retarded	2.2	0.0	13.2	12.2	28.6	19.5	56.0	68.3*
Control	2.2	1.1	19.1	17.4	29.2	21.7	49.4	59.8
High Control	2.5	0.0	20.0	22.8	35.0	22.8	42.5	54.3*
Syllables								
Retarded	23.7	10.3	21.0	16.4	38.6	48.3	16.7	25.0
Control	14.9	8.7	21.0	24.6	47.4	43.6	16.7	23.0
High Control	14.9	3.9	19.1	27.4	48.9	49.0	17.0	19.6
Sentences								
Retarded	13.5	15.8	48.9	37.7	30.8	32.9	6.8	13.7
Control	11.4	14.6	47.3	41.7	29.0	26.4	12.2	17.4
High Control	10.4	13.6	52.1	42.4	27.1	20.3	10.4	23.7

N = Percentage of error frequency in neutral situation.
R = Percentage of error frequency in reward situation.
* = Difference significant between the .10 and .20 levels.

Thus, the retarded reader's higher proportion of transposition errors on this test may signify a lower level of ability to transpose correctly than is possessed by the good reader.

The data in Table XV suggests that the better the reader the

better his ability is to transpose.

Syllables

In contrast with the digits tests, the major error here is not transposition but substitutions: a reflection perhaps of the greater demands in auditory discrimination, made by this test.

If substitutions are looked upon as constituting the "best error", the retarded readers improve their proportion from thirty-nine to forty-eight per cent. In the neutral situation particularly, the retarded group has a greater tendency to add sounds and syllables, sometimes, to make words of the stimulus sounds.

Sentences

Most errors in this test consisted of some form of paraphrase of the sentence which involved substitutions, frequently accompanied by omissions or additions. The error most frequently occurring alone was the error of omission, generally of an adverb or adjective.

Table XV confirms that in the two groups the commonest error, on the test of sentence memory, was that of omission, with substitution errors next in order of frequency. As with the other tests, in the reward situation more students made

errors of transposition, while fewer made omissions.

Summary of error analysis

In brief it may be said that, an analysis of the errors made by students participating in this study, suggests the following of the retarded reader:

(i) In digits forward tests, he tends to make fewer errors of transposition than the good reader.

(ii) In digits backward tests, he tends to make a higher proportion of incorrect transpositions, with relatively fewer omissions than the better readers.

(iii) In syllable tests the retarded reader- especially if the task is new or his motivation low, is more likely to add extraneous sounds or syllables, than does the better reader.

(iv) In sentences, the retarded reader is more likely than the good reader to add or substitute words or phrases and less likely to transpose them.

The most significant of the differences in error frequency noted above, is that for the proportion of transposition errors on the test of digits backwards. Here the difference in proportion between the total retarded group and the high control sub-group, falls between the .10 to .20 levels of significance.

Of observations (iii) and (iv) above, it may perhaps be surmised that the retarded reader brings his errors to the memory task, in the form of expectations, rather than omitting or confusing what he actually hears, as the good reader seems more prone to do.

VI. SUMMARY OF SIGNIFICANT FINDINGS ON THE TESTS OF AUDITORY MEMORY

The analysis of the data, described in this chapter, revealed differences in performance between the groups, or between neutral and reward performances, significant at the levels indicated in the summary which follows.

Neutral Situation. The mean score of the high control subgroup exceeded that of the total retarded group on the test of digits backwards, by a difference significant at the .12 level of significance. A similar difference on the test of digits combined was significant at the .08 level.

Improvement from neutral to reward situation. The retarded group improved their scores on digits combined and digits forward, to a degree significant between the levels of .05 to .10. The control group made gains in the same range of significance, on the tests of digits combined, and digits backwards.

Reward Situation. When the mean scores of the high control sub-group were compared with the means of the total retarded group, the superior readers out-performed the retarded readers to a degree significant at the .05 level on the tests of digits backwards, and digits combined.

The same comparison on the test of syllables, favoured the control group at the .10 level of significance, and on the test of sentences the difference was significant at the .09 level, again favouring the superior readers.

VII. SUMMARY OF CHAPTER IV

In this chapter, the data was analyzed and interpreted. Initially, mean scores of the total groups were compared, first in the neutral situation and then in the reward situation.

Next, the gains made by the retarded readers were described, and compared with the control group gains.

Apparent differences observed between the total groups, were further examined by comparing total-group mean scores, with the mean scores of high control and low retarded sub-groups.

An analysis was also made of the number of individuals in each group who improved their performance on the auditory tests, from the neutral to the reward situation.

Finally, the errors made by the members of the two groups were analyzed and compared for frequency of occurrence.

The conclusions and implications drawn from the data thus described, are presented in Chapter V.

CHAPTER V

FINDINGS AND CONCLUSIONS

In this investigation thirty boys from Grade IV, Grade V, and Grade VI, retarded in reading, were tested on five measures of auditory memory. The boys were tested twice - initially in a neutral situation, and again, after a two-week interval, under reward conditions. A group of thirty readers, randomly selected from the same classes, constituted a control group, which attempted the same tests in the same two types of situation.

Comparisons were made to determine the degree of improvement made by each group under reward conditions, and other comparisons were made between the groups to determine whether one group significantly out-performed the other in either the neutral situation, the reward situation, or in degree of improvement.

It was the aim of the investigator to compare the auditory memory ability of retarded readers with average readers, to determine whether retarded readers have a poorer auditory memory than average readers, and, if so, whether reinforcing motivation overcomes this weakness for the poor readers. Comparisons were also made between sub-groups of

the best, and the most retarded readers in the study.

This chapter will present the null hypotheses, and indicate the degree to which they were negated, or supported, by the data described in Chapter IV. Conclusions drawn by the investigator will also be included, together with suggestions for further research.

I. VERIFICATION OF HYPOTHESES

Hypothesis One

> In the neutral situation there is no significant difference between the mean scores of retarded readers and mean scores of the control group, on the tests of auditory memory.

Although on seven of the eight mean scores calculated, the control group out-performed the retarded group, the differences were not significant at the .05 level. Greatest difference occurred between mean scores for sentences, with $p = .17$. The null hypothesis was therefore sustained for the total groups.

When the same null hypothesis was applied to the mean scores of the total retarded group and a control sub-group composed of the best readers, the null hypothesis was still sustained, if the .05 level is taken as the required level of confidence. However, between the unit scores for digits combined, the difference was significant at the .08 level,

with the superior readers out-performing the retarded group. Much of this advantage arose from the test of digits backwards, where the difference in means had a probability of .12.

Hypothesis Two

> In the reward situation there is no significant difference between the mean scores of retarded readers and the control group on the tests of auditory memory.

In the neutral situation the total control group again achieved mean scores superior to those of the total retarded group, this time on all eight scores calculated. However, none of the differences reached the .05 level of significance. Differences having the greatest significance occurred on the measures of sentences ($p = .20$) and digits backwards (span scores) where $p = .22$. These differences were not sufficient to disprove the null hypothesis for the total groups.

Hypothesis Two was also applied to the mean scores of the sub-group of superior readers and the total retarded group. Differences in mean scores for digits forward, syllables and sentences failed to reach the .05 level of significance, and on these tests the null hypothesis was therefore upheld. However, the tests of digits backwards and digits combined yielded differences significant at or above the .05 level of significance, on both span and unit scores. For these measures, therefore, the null hypothesis was disproved.

Thus, on the measures of digits backwards and digits combined, retarded readers scored significantly lower than superior readers.

Hypothesis Three

> In the reward situation there is no significant improvement in the mean scores of the retarded readers on the tests of auditory memory.

The null hypothesis was upheld on all tests if the .05 level of significance is demanded. However, retarded readers showed a marked difference in mean scores for the test of digits forward and digits combined. The significant value of t = 1.699 at the .05 level, and the two tests named showed gains with t = 1.609 and 1.647 respecitvely, (p = .07 and .06). Conversely, gains made by the retarded readers on the test of digits backward were very small, with span scores showing no increase at all.

While the hypothesis did not include the control group, the same comparisons were made for it, with interesting results. With the significant value of t = 1.699, the digits combined score showed a gain with a value of t = 1.694 (p = .06). Unlike the retarded readers, however, this gain is largely attributable to backward digits, where the span gain had a t value of 1.469, i.e. the probability is between .05 and .10. On forward digits the control group made only small

gains, but the increase in score on the sentence test also fell between the .10 and .05 levels of significance.

Thus, close to significance at the .05 level were the gains made on the tests of digits combined and digits forward for the retarded group, and the tests of digits combined, digits backwards, and sentences for the control group.

Hypothesis Four

> In the neutral and reward situations there will be no significant difference between retarded and control groups in the relative frequency with which the various types of error occur.

When the various errors made were listed according to their frequency of occurrence, it appeared that there were some differences between the two total groups, in the kind of error made. When the error-pattern of the high control subgroup was analyzed certain of these trends were confirmed. As summarized in the preceding chapter, the retarded readers in this study appeared to make fewer errors of transposition on the digits forward test than did the better readers. On digits backwards, where the task was to transpose the digits, they made more errors in transposition than the control group. On tests of syllables and sentences, errors of the retarded reader appeared to arise from reporting what he expected to hear, so that sentences were paraphrased and some syllables

turned into words. The control group tended to make more errors with what they actually heard, i.e. emitting or transposing, rather than adding or substituting.

None of the differences in error-frequency between the groups was significant at the .05 level, so that the null hypothesis was upheld. Greatest difference was in the proportion of transposition errors on the test of digits backwards, where, when the high control sub-group was compared with the total retarded group, the difference was significant at a level between .10 and .20.

Number of Students Showing Improvement

While no formal hypothesis was stated, as a concommitant of Hypothesis Three, a comparison was made of the number of individual students, and individual scores in each group, changing for the better or the worse. Summarizing the data previously presented, it appears that the total number of individuals and individual scores improving in the reward situation is practically identical for the two groups. The retarded group has a slightly larger proportion of lower scores, and individuals with lower scores, than appear in the control group. Thus, on balance, the control group showed a slightly better record as far as frequency, rather than degree of improvement, is concerned.

Among individual tests, more control readers improved on digits backwards, with slightly more retarded readers doing better on digits forward.

Degree of Improvement

No formal hypothesis was stated in this connection, but proportionate gains made by the two groups were compared to see whether one group appeared to make greater relative gains than the other. This comparison, illustrated by Figure 6 and 7, pages 81 and 82, indicated that with similar gains on digits combined and sentence memory, the groups differed on forward digits, where retarded readers made a much larger gain, and on backward digits, where an even larger discrepancy favoured the control group. Retarded readers also made a greater proportionate gain on syllables.

When mean proportionate gains are compared, percentages of 5.77 and 5.45 are obtained, slightly favouring the control group.

Thus, in summary, it may be said that on two scores gains were proportionately equal, gains on two other scores favoured the retarded readers, and on one score the control group had the greater gain. However, the gain here (backward digits) was such that on all scores combined, the control group had the higher mean gain score. None of the differences in gains between the groups, was significant at the .05 level.

II. CONCLUSIONS DRAWN FROM THE STUDY

In the light of this study, answers can now be attempted to the questions posed in Chapter One.

Do retarded readers as a group score significantly low on tests of auditory memory?

The two testing situations of this study yielded sixteen score-comparisons between the total groups. On one measure only the mean span scores were equal. On the other fifteen measures, the mean score for the retarded readers was lower than for the total control group.

When these comparisons were made between the retarded group and a sub-group of the best readers, the observed differences widened.

In terms of significance, none of the differences between the total groups reached the .05 level of confidence, nor was this significant level reached in comparisons between the retarded readers and the sub-group of superior readers in the neutral testing situation. However, in the second testing under reward conditions, when retarded readers were matched against superior readers there were significant differences at the .05 level on the tests of digits combined and digits backwards. Differences were not significant at the .05 level

for digits forward, sentences or syllables.

Thus, the answer to the question posed would appear from this study to be that retarded readers, when compared with good readers, score lower on auditory tests of syllables, sentences, digits forward, and digits backward. Their scores are significantly lower, at the .05 level, on the tests of digits backwards and digits combined when attempting these tasks for the second time and/or under reward conditions.

Does increased motivation significantly improve the performance of retarded readers on tests of auditory memory?

On span scores for digits backwards, retarded readers made no increase in mean score, with unit scores for the same test showing only a small increase. A sizeable increase occurred in syllables, and a larger one in sentences. Greatest gain was on the test of digits combined (unit scores), where the gain was significant at the .06 level, with an accompanying increase significant at the .07 level, for digits forward.

In short, reinforcement of motivation apparently caused retarded readers to improve on all measures - nearly significantly on digits forward (among single tests) and least significantly on digits backwards. It is noteworthy that, in the neutral situation, the severely retarded readers had

the lowest score of any group on the digits forward test, while in the reward situation they did better than both total groups.

It may be that the test of digits forward is the purest test of auditory memory among those employed, since it does not make the acuity demands of the syllable test, nor does it allow the retarded reader as much opportunity to confuse what he hears, with what he expects to hear, as do the syllable and sentence tests. A listener may expect a syllable to be a familiar one, or a sentence to be structured in a customary way, but there is less likelihood of such presuppositions affecting the perception and recall of an unsequential series of numbers.

If this assumption is correct, and the digits-forward test is the purest measure of auditory memory used in this study, then it may be said that increased motivation or practice, does improve the auditory memory of retarded readers, significantly at the .07 level. Further, this improvement may be greatest for severely retarded readers.

Do retarded readers suffer from poor auditory memory, lack of concentration, or both?

Two groups of students having the same approximate age and I.Q. could be expected to perform at very similar levels,

on tests of auditory memory. In fact, this similarity of performance is evident on the reward performance of the digits forward sub-test, the measure which, it is suggested, most purely measures auditory memory among tests used in this study. These closely approximate scores on digits forward occurred in the reward situation, and to obtain these particular levels each group improved from the neutral situation. As indicated on Figure 6, page 81, the percentage increases were .6 for the control group and 5.2 for the retarded group, or in terms of unit scores, 4.4 per cent and 11.9 per cent. If the scores on the second testing represent optimum levels, then the great improvement required to reach this level by the retarded group, suggests that their initial performance was quite considerably below their capacity. While it is true that reward can affect memory either at the perception level or the recall level, the very brief interval during which the material is "held" during this test, suggests that the improvement arose mainly from sharpened perception of the stimulus, in turn attributable to greater concentration.

That attention and concentration were greater under the reward conditions was very evident during the testing. The prospect of winning a candy-bar roused the interest of the children, but the race-track on which each student

followed his own progress, seemed to be a greater motivating influence with boys in both groups.

While, however, it appears that lack of attention arising from poor motivation may be the cause of the retarded readers' poor auditory memory for digits forward, it is clear that on the other tests some additional factor must be at work, for although the retarded reader improves his performance on the sentence and syllable tests, so do the members of the control group, so that relatively the retarded reader does not improve his sentence or syllable score, by comparison with the total control group.

Digits Backwards

The test of digits backwards yielded the most significant results found in this investigation, thus agreeing with the findings of Starr (1924), McCauley (1928), Stauffer (1948) and Johnson (1955). In this study -

1. Backward digits is the test which least differentiated the total groups in the neutral situation, ($p = .76$).
2. It is the single test which most differentiated the subgroup of best readers from the total group of retarded readers, in the neutral situation, ($p = .12$).
3. It is the single test which shows most difference in degree of improvement from neutral to reward situation, as

between the total groups, with the advantage to the control readers.

4. It is the one test on which, by span scores, retarded group failed to improve in the reward situation.
5. It is the only single test which produced differences significant at the .05 level between the best readers and the retarded group, (in the reward situation).
6. It is the only single test on which the severely retarded readers scored below the mean of the total retarded group.
7. It is the only single test on which the .05 level of significant difference is maintained, when the high control sub-group is compared with the severely retarded sub-group.
8. It is on this test that the most significant difference was found for the frequency, with which a certain type of error occurred. (The transposition error with p = .20 to .10).

Conclusions Concerning the Test of Digits Backwards

The test of digits backwards appears to have possibilities as a tool for identifying retarded readers, particularly on the second administration of the test. It may also be that this weakness is thrown into greater relief, in the case of severely retarded readers, by a higher than average score on

digits forward. In this study, the mean of the severely retarded readers on the test of digits forward, reward situation, was higher than that of the total control group.

Certainly this inverse relationship deserves further investigation. It is necessary to bear in mind however, that the higher digits-forward score only appeared in the reward or repeat situation, as did much of the discrepancy in the digits backwards scores.

Possible Reasons for the Difference in Backward Digit Scores

If the view is accepted that the improvement in digits forward is caused by the greater concentration incurred through reinforcement, then why does a similar improvement not occur in digits backwards? The following data compiled from Tables IX and X, pages 88 and 94, suggests a possible answer:

	Digits Backward Neutral Score	Digits Backward Reward Score	Increase in Mean Score
Low Retarded Group	16.67	16.75	.08
Total Retarded Group	17.87	18.27	.40
Total Control	18.60	20.77	2.17
High Control	23.33	25.75	2.42

Of interest here is the contrast in the size of the gains made. It is apparent that, as a group, both average and good readers made greater gains than poor and very poor readers, thus increasing the initial discrepancy in scores.

If the assumption is made that the groups responded equally to the motivational reinforcement, then practice may have been responsible for the rest of the difference. It was observed during the pilot study, that on this particular test, learning seemed to occur during the testing. Thus some students who took two attempts before they could reverse the order of three and four digits, went on to reverse five and six digits at the first try.

May there be some general cognitive ability which readers possess to a greater degree than non-readers, and which relates to the digits backwards test? In that event, the superior reader who possesses this general ability to the greatest degree, will master the digits backwards task with the least amount of practice; the average reader, with an average share of this proposed ability, will need more practice; while the poorest readers will make least gains with the practice provided on these two testings. Such a supposition fits the data given above.*

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* It cannot, however, be claimed that such learning has been proved to take place. Any learning during the neutral test cannot be measured, while the difference in the mean gain scores was not significant at the .05 level when a non-parametric test of rank-order was applied.

The nature of this general ability is suggested by the digits backwards test and by the error most committed on it by the retarded group. In the test the subject is given auditorily a series of sounds (digits) which he must hold in correct sequence in his mind, meanwhile speaking aloud the same digits in a different sequence. The retarded readers in this study did not most frequently omit, substitute, or add to the sequence given, but rather confused the order of the original sequence. Otherwise stated, the ability called upon in the digits backwards test is to hold in mind a sequence of digits while operating upon it. By the evidence of their digits forward scores, the retarded readers are not significantly disabled in holding a sequence; it is apparently being required to do the two things simultaneously which troubles them. It may be this same disability which is the cause of the low arithmetic scores, reported by investigators studying WISC sub-test results.

The Effectiveness of the Measures Used

Digits Tests. While the tests of digits forwards and digits backwards clearly differentiated between the students, it was noted that certain students transposed digits to put them in serial order, and that in two places the stimulus-series is

so structured that it encourages this error. Thus among the forward digits, the numbers 4-2-3- follow one another in one sequence, and in a backward series there again occur the numbers 2-3-4-2.

Another error, not related to the structure of the test, was for students to substitute five for nine, and vice versa. This error occurred more frequently on the digits-backwards test.

In general, apart from the seriation problem, the tests appeared satisfactory.

Syllables. As the results show, this test also differentiated among the students, and appeared to be generally satisfactory. Much of the test's difficulty lies in the demands it makes on the student's powers of auditory discrimination, and the examiner has to pay close attention not only to his own enunciation, but also to the subject's. Final consonants seemed to cause problems, notably d, m and n. Two lines were the cause of frequent errors: ind-oom-oint-ily, and erd-ast-zen-ightful. It would therefore appear that it is not the number of syllables, but the particular syllables, or their sequencing, which creates the difficulty.

As stated, it was felt that the test was generally satisfactory.

Sentences. The sentence test is related to the syllable test, in that the number of syllables does not completely account for the difficulty of a series. Certain sentences proved more difficult than longer ones which followed them, and often the difficulty seemed connected with how well the sentence scanned. The more balanced sentences seemed less likely to suffer from omissions or additions. Thus there may be a rhythmic factor involved here.

In general the measure seemed effective, but it would be advantageous to have a similar test which tried to measure the other factors which make for difficulty in remembering sentences, apart from mere length.

Effectiveness of the Motivational Reinforcement Measures

It seems evident from the results obtained, and in particular from the count of the number of students who improved their performance in the reward situation, that either practice or reward did affect the majority of students. It appeared to the examiner that the prospect of winning a candy bar added considerable interest to the second testing. It was felt however, that the "game" element was considerably more important in sustaining the subject's motivational level. That the student moved his own marker flag seemed to increase his participation in the testing, and it was notable that

when his previous performance had been surpassed, the subject was still anxious to move his flag as far ahead as he was able. Thus the "game" element, in which he was playing only against himself, sustained the effort beyond the limits required to win the candy bar.

Summary of Conclusions and Implications

Results of this study bear out the general findings that retarded readers do less well on tests of auditory memory than do superior readers. However, the only tests on which differences emerged, significant at the .05 level, were the tests of digits combined, and digits backwards in the reward situation.

The reinforcement procedures appeared to be successful, resulting in comparable gains for both groups. A large gain in memory for digits forward, shown by the retarded readers, was taken as evidence that when not deliberately motivated, retarded readers lose marks on this test because of lack of concentration.

The failure of the retarded readers to match the improvement of the control group on the test of digits backwards, was noted, and it was postulated that retarded readers might lack a general cognitive ability called into play by this test. The ability was tentatively described as,

being able to hold a sequence in mind, while operating upon its component parts.

It was suggested that the digits backwards test might be valuable for identifying possible reading problems, and there is some evidence in this study that severely retarded readers while being poorest in digits backwards, are also above average on digits forward. Thus the contrast between these abilities and the norms for his age and I.Q. may help identify the child who will have trouble in reading.

III. SUGGESTIONS FOR FURTHER RESEARCH

1. Results of this study should be confirmed by one using greater numbers of students. Since these measures appear to be most significant, the study could be restricted to the tests of digits forward and digits backwards.
2. The same, or a different study should attempt to determine whether the improvement in digits forward scores, observed among retarded readers in this study, arose from the reinforcement procedures or practice, or both.
3. A similar question needs answering for the observed rise in the digits backwards score of the adequate readers. Was this rise the result of practice, or of the reinforcement procedures, or both?

4. How valuable is the digits backwards / digits forwards dichotomy, as a tool for identifying poor readers? This question needs investigating, but any researcher would need to be assured that the retarded reader was sufficiently motivated at the time of testing, to achieve a score truly representative of his memory for digits forward.

5. If the digits backward test is calling into play some such faculty as that suggested, how is this related to reading? Information on this point might be obtained by devising tests somewhat similar to the digits backward test but requiring other transpositions, or employing different units. Thus from a sequence of digits, the subject might report the odd and even digits, or digits might be replaced by letters, and changes required in their order. Further, if the stimulus sequence were presented visually instead of aurally, would the retarded reader still have difficulty with the backward-digits type of task?

A battery of tests built on the pattern of the digits-backwards formula, would help to further explore this area of recall-flexibility, and might well prove a useful diagnostic tool for detecting cases of reading difficulty.

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APPENDIX

Digit Span. Name	Total Items Tried	Add.	Om.	Sub.	Trp.	Unit Score
3-8-6						
6-1-2						
3-4-1-7						
6-1-5-8						
8-4-2-3-9						
5-2-1-8-6						
3-8-9-1-7-4						
7-9-6-4-8-3						
5-1-7-4-2-3-8						
9-8-5-2-1-6-3						
1-6-4-5-9-7-6-3						
2-9-7-6-3-1-5-4						
5-3-8-7-1-2-4-6-9						
4-2-6-9-1-7-8-3-5						
2-5						
6-3						
5-7-4						
2-5-9						
7-2-9-6						
8-4-9-3						
4-1-3-5-7						
9-7-8-5-2						
1-6-5-2-9-8						
3-6-7-1-9-4						
8-5-9-2-3-4-2						
4-5-7-9-2-8-1						
6-9-1-6-3-2-5-8						
3-1-7-9-5-4-8-2						

Syllables	Add.	Om.	Sub.	Trp.	Score
tan dy					
thor ot					
is duc					
can en ow					
ass ing all					
eer am et					
ab eas ate ery					
fo ly on ild					
ind oom oint ily					
ay haps ex ger al					
erd ast zen ight ful					
dis vol ute ac tory					
pher ment ish di struct able					
cho ell gant er mem cher					
gu lar tis moa fi sion					

Instructions

"I am going to say some syllables to you. Listen carefully, and when I get all through I want you to say just what I said. Tell the syllables in the same order, as I read them."

Syllables are read at the rate of one per second.

Practice syllables: eav and

For correct pronunciation, see the page following.

Auditory Memory - Syllable Recall Test

Guide to Pronunciation

tan (han)dy

thor(n) (h)ot

is duc(k)

can (p)en (c)ow

ass (br)ing all

(st)eer am (m)et

(st)ab eas(t) ate (bak)ery

fo(e) (ho)ly on (w)ild

(w)ind(ow) (b)oom oint(ment) (read)ily

(d)ay (per)haps ex(tra) (dan)ger al(ley)

(h)erd (v)ast (fro)zen (l)ight (care)ful

dis(tance) vol(ume) (c)ute ac(cent) (his)tory

(ci)pher ment(or) (f)ish di(agonal) (con)struct (read)able

cho(sen) (disp)ell (ele)gant (st)er(n) mem(ber) (lec)ture

(re)gu(lar) lar(k) (ar)tis(t) moa(n) fi(nal) (illu)sion

Sentences	Add.	Om.	Sub.	Trp.	Score
1. The doll has pretty hair.					
2. We will go for a walk.					
3. My dog chases the white cat.					
4. Our new car has four red wheels.					
5. Henry likes to read his new book.					
6. Bring the broom and sweep the front room.					
7. The bell on the engine rings loudly.					
8. On Sundays all of us go to church.					
9. In summer we go North where it is cool.					
10. Green leaves come on the trees in early spring.					
11. The airplane makes a loud noise when it flies fast.					
12. We saw a little fire on the way to school.					
13. The sun shone brightly today and it hurt my eyes.					
14. The men painted our new house white with dark green blinds.					
15. They gave her some pretty shoes for her birthday last month.					
16. The art teacher comes to our own school three days a week.					
17. Ten persons went to a party where there was lots to eat.					
18. Three boys spent a happy day last week on a fishing trip.					
19. On Tuesday for lunch we had some fresh bread which our Mother baked.					

Sentences	Add.	Om.	Sub.	Trp.	Score
20. Father must buy some new licence plates for his car once each year.					
21. When the train passes the whistle blows for us to keep off the track.					
22. In the summer time the nights are very short and the days are long.					
23. We had a party for Jean last Monday with cake and ice cream to eat.					
24. At eight we go to bed and Mother reads to us from our story books.					
25. Each year when the big circus comes to town Father takes the whole family.					
26. Many boys and girls go to the movies on nights at the end of each week.					
27. My sister Mary has a pretty new doll which shuts its eyes and goes to sleep.					
28. The man who lives next door is a good neighbour and invites us for many rides.					
29. Last winter we made a big round snow man and put a little black hat on his head.					
30. In my uncle's home there was a soft red carpet on the floor of the living room.					
31. The day of the football game the weather was clear but chilly and the wind blew briskly.					

Sentences	Add.	Om.	Sub.	Trp.	Score
32. Because there were few vacant lots the police roped off our street so that we might be safe.					
33. On the Fourth of July my father puts on his army suit and joins his friends on parade.					
34. In fair weather and at high tide ships from many nations set sail for their own distant ports.					
35. The baseball team from our high school played fifteen games; they lost six but they ended in second place.					
36. Last night there was a large banquet at the hotel where many people dined and had a pleasant time.					
37. Our reading books at school have many fine stories which are short but very full of life and action.					
38. In the north country the days are very short in winter and the sun hangs low in the southern sky.					
39. China closets filled with all kinds of dainty dishes and cut glass lined the large walls of the dining room.					
40. On cold, clear nights hundred of thousands of twinkling stars shine brightly from their cradles far up in the sky.					

Sentences	Add.	Om.	Sub.	Trp.	Score
41. In the heart of the Congo there are many kinds of beasts which are a nightly terror to the natives.					
42. Down near the bank of the river is an estate from which sound the shouts of happy children hour after hour.					
43. Each four years voting takes place which results in many men being placed in office for terms of two years or more.					